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March 29, 2021

NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
Jeryl Gardner, PE, CEM, Supervisor
Abandoned Mine Lands Branch
Bureau of Corrective Actions
901 S. Stewart Street, Ste 4001
Carson City, NV 89701

> **RE:** **Final Combined Operable Units 4b, 5, and 6 Remedial Investigation Report**
> **Anaconda Copper Mine Site**
> **Lyon County, Nevada**

Dear Mr. Gardner,

Attached is the Final Combined Operable Units 4b, 5, and 6 Remedial Investigation Report for the Anaconda Copper Mine Site in Lyon County, Nevada.

Please contact me via email or at the telephone number listed above if you have any questions or comments.

Thank you.

Sincerely,

Nick Peterson, P.G.
Liability Manager
Remediation Management Services Company
An Affiliate of Atlantic Richfield Company

Atlantic Richfield Company

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Final Combined Operable Units 4b, 5, and 6 Remedial Investigation Report

Anaconda Copper Mine Site
Lyon County, Nevada

Prepared for:
Atlantic Richfield Company
201 Helios Way, Houston, TX 77079

March 29, 2021
Project No. SA18170340

Atlantic Richfield Company

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Final Combined Operable Units 4b, 5, and 6 Remedial Investigation Report

Anaconda Copper Mine Site
Lyon County, Nevada
Project No. SA18170340

Prepared for:

Atlantic Richfield Company
201 Helios Way, Houston, TX 77079

Prepared by:

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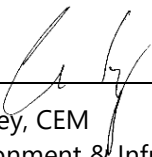USA
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Submitted to:

Nevada Division of Environmental Protection
Jeryl Gardner, PE, CEM, Supervisor
Abandoned Mine Lands Branch
Bureau of Corrective Actions
901 South Stewart Street, Suite 400
Carson City, Nevada 89701
USA

March 29, 2021

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Jurat

I hereby certify that I am responsible for the services in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances.

_____   March 29, 2021
                                             _____

Charles E. Frey, CEM   Date
Wood Environment & Infrastructure Solutions, Inc.
Associate Soil Scientist
EM – 2462, Expires 10/10/22

The following individuals contributed significantly in the preparation of this document:

Joe Gonzales, Senior Geologist, Wood Environment & Infrastructure Solutions, Inc.

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Final Combined Operable Units 4b, 5, and 6 Remedial Investigation Report
Anaconda Copper Mine Site / Lyon County, Nevada

Executive Summary

Introduction

On behalf of Atlantic Richfield Company (ARC), Wood Environment & Infrastructure Solutions, Inc. (Wood), has prepared this *Final Combined Operable Unit 4b, 5, and 6 Remedial Investigation Report* for the Anaconda Copper Mine Site (ACMS) in Yerington, Nevada (Figures 1-1 and 1-2). This report was prepared in accordance with the *Interim Administrative Settlement Agreement and Order on Consent* for the ACMS (IAOC) (and the IAOC Appendix B Statement of Work for Site-Wide Remedial Investigation and Feasibility Study [RI/FS SOW]) between the Nevada Division of Environmental Protection (NDEP) and ARC dated February 5, 2018 (NDEP, 2018). The remedial investigation described in this report was conducted in accordance with the *Final Combined Operable Unit-4b, Unit-5, and Unit-6 Remedial Investigation Field Sampling and Analysis Plan* (Wood, 2019) approved by NDEP on May 8, 2019 and consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as stated in the National Priorities List Deferral Agreement between the U.S. Environmental Protection Agency (U.S. EPA) and the NDEP (U.S. EPA, 2018).

ARC received NDEP comments on the draft version of this report (submitted on October 15, 2020) on January 13, 2021. NDEP's comments are addressed in this final version. A response to comments table containing specific responses to NDEP comments is provided in Appendix 1A.

This document presents the RIs for Operable Unit (OU) -4b (Sulfide Tailings), OU-5 (Waste Rock Areas), and OU-6 (Oxide Tailings). Originally, the RI/FS SOW grouped OU-2 (Pit Lake), OU-4b, OU-5, and OU-6 together for the purposes of RI characterization activities. However, the RI/FS SOW also stated that the OUs could be separated into different RI Reports as technically appropriate or necessary (NDEP, 2018).

Accordingly, OU-2 has been separated into its own RI Report, as it has different properties and characteristics and the schedule for data collection and evaluation was different from the other OUs. The RI for OU-2 is presented in the *Draft Pit Lake Operable Unit 2 Remedial Investigation Report* (Wood, 2020f).

OU-5 is composed of three main waste rock areas: W-3 Waste Rock Area (W-3), S-23 Waste Rock Area (S-23), and the South Waste Rock Area (South WRA). The RI for W-3 and S-23 was completed previously, as presented in the final *Operable Unit 8 Peripheral Areas Remedial Investigation, Risk Characterization, and Feasibility Study* (OU-8 PA RI/FS) (Wood, 2020a). Evaluation summaries and key conclusions for W-3 and S-23 are included in this report to create a comprehensive description of OU-5.

Shallow groundwater beneath OU-4b, OU-5, and OU-6 has been evaluated in the *Final Remedial Investigation Report, Site-Wide Groundwater Operable Unit (OU-1)* (OU-1 FRIR) (Copper Environmental Consulting [CEC], 2020). Where relevant, groundwater-related findings from the OU-1 FRIR have been included in this report. However, this report is not intended to update or change the conclusions presented in the OU-1 FRIR.

Operable Units Descriptions

OU-4b – Sulfide Tailings

The sulfide tailings occupy a total surface area of approximately 600 acres (Figure 2-1). OU-4b is located north and northeast of the OU3 Process Area, and east of OU-4a and OU-6. The Wabuska Drain (OU-7) originates north of OU-4b. The estimated volume of mining-related material in OU-4b is approximately 55 million cubic yards. The estimated volume was calculated using a three-dimensional conceptual model

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with the Groundwater Modeling System (GMS) software package (Aquaveo™, 2017) and OU-4b information described in Section 4.2.2.

In general, the thickness of the mining-related material increases from approximately 15 to 30 feet in the south to approximately 40 to 68 feet to the north. The thickness of the tailings was also estimated using GMS, and details of the volume and thickness estimation process are described in the *Final Combined Operable Unit-4b, Unit-5, and Unit-6 Remedial Investigation Field Sampling and Analysis Plan* (Combined FSAP) (Wood, 2019). Both the tailings volume and thicknesses were updated and supplemented with direct measurements from select boreholes as described later in Section 4.2 of this RI Report.

When mining operations ceased in 1978, approximately 95 percent of the surface of the sulfide tailings was covered with oxide tailings also referred to as vat leach tailings (VLT). As part of a removal action conducted in 2006 to address dust concerns, the EPA covered most of the remaining exposed sulfide tailings with VLT (CH2M Hill, 2010). The GMS-estimated 55 million cubic yards of mining-related material in OU-4b consists of approximately 49 million cubic yards of sulfide tailings and approximately 6 million cubic yards of VLT. Appendix 2B presents historical aerial photographs which show the mining activities in OU-4b through time.

OU-5 – Waste Rock Areas

Three waste rock areas (WRAs) – W-3, S-23, and the South WRA (Figure 1-2) comprise OU-5. The three WRAs have a combined area of approximately 506 acres.

The present-day area of W-3 covers approximately 80 acres, although the size of W-3 has varied through its history. W-3 is present north of the pit (OU-2), south of OU-3 and Burch Drive, and is adjacent to the OU-8 Phase I/II and Phase IV Slot heap leach pads (HLPs) (Figure 1-2). W-3 is in OU-5 and contains low-grade oxide ore with approximately 0.2 percent (%) to 0.3% copper. The W-3 area was developed by piling excavated material from the open pit beginning in 1953 (BC, 2009) and expanded in various directions over an approximately 25-year period. At its largest extent, W-3 encompassed approximately 170 acres (CH2M Hill, 2010). The W-3 side slopes are generally 1.4 horizontal (H):1 vertical (V) and have a maximum height of approximately 210 feet, although the side slopes may be steeper in terraces located north of the Slot.

S-23 is in OU-5 and covers approximately 19 acres. S-23 generally consists of low-grade sulfide ore stockpiled west of the OU-8 Phase I/II HLP and south of the Solvent Extraction/Electrowinning Process Area (Figure 1-2). S-23 was originally constructed by Anaconda Copper Mining Company beginning in 1953 during excavation of the open pit (BC, 2009a) and has been identified on historical maps as "Sulfide Tailings," "Low-grade Sulfide Ore," or "S-23 Waste Rock." The side slopes are generally 1.4 H:1 V and have a maximum height of approximately 110 feet (CH2M Hill, 2010). S-23 has been characterized in the OU-8 PA RI/FS (Wood, 2020a).

The South WRA is the largest of the three WRAs, covering an area of approximately 407 acres. The South WRA is located South of the pit (OU-2) (Figure 2-2). It contains most of the approximately 90 million tons of alluvial material removed above the ore body and another approximately 25 million tons of waste rock that was associated with the ore. The side slopes are generally sloped 1.4H:1V and have a maximum height of approximately 160 feet (CH2M Hill, 2010). Using the GMS software package along with direct measurements presented in Section 5.2, the volume of the South WRA is estimated at approximately 73 million cubic yards.

OU-6 – Oxide Tailings

The current extent of the OU-6 area covers approximately 300 acres. OU-6 is located north of the OU-8 Phase III-3X HLP, west of the Calcine Ditch portion of OU-4a, and southwest of the OU-8 Phase IV-VLT

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HLP (Figure 2-3). The areal extent of VLT across the ACMS is challenging to estimate as VLT has been used at the ACMS as a cover material across multiple OUs, as described further in Section 6.2. The VLT in OU-6 has an average height exceeding 100 feet (CH2M Hill, 2010) and an estimated maximum thickness of approximately 190 feet, as estimated using the GMS software package (Appendix 2A). The side slopes generally range from 1.3H:1V to 1.5H:1V. The top surfaces are composed of multiple benches and VLT mounds. Using the GMS software package, the estimated volume of VLT remaining in OU-6 is approximately 49 million cubic yards.

OU-4b – Sulfide Tailings Remedial Investigation

The RI information for OU-4b is presented in this section.

Recent OU-4b Remedial Investigation Summary

Materials in and underlying OU-4b were sampled from 2019 through 2020 (2019-2020) as part of the RI as planned in the Combined FSAP (Wood, 2019). The scope of the investigation consisted of the collection of soil samples from 29 shallow and six deep boreholes. To provide a sufficient and statistically valid dataset for the RI and risk assessments, soil samples were collected at a total of 35 randomly selected locations throughout OU-4b. For the shallow boreholes, sampling was performed at four discrete intervals, to a total depth of approximately 15 feet below ground surface (bgs). The six deep borehole locations were advanced through the sulfide tailings to native soil. Once the native soil interface was encountered, boreholes were advanced an additional 20 feet and sampled to characterize the vertical and lateral variability of geochemical concentrations as well as potential impacts to the underlying native soil.

OU-4b Nature and Extent of Contamination

This section presents the nature and extent of contamination for OU-4b, primarily utilizing the data collected in 2019-2020. It includes a discussion of constituents of interest (COIs), material types, metals and radionuclide results, meteoric water mobility procedure (MWMP) results, and acid base account (ABA) results.

Constituents of Interest

The OU-4b data were evaluated against background concentration limits (BCLs). In this RI, the soil COIs are compared to BCLs as developed in the *Background Soils Data Summary Report* (Background Soils DSR) (BC, 2009b). The Background Soils DSR developed BCLs for two different soil types, designated Sub-Area A-1 and Sub-Area A-2. Sub-Area A-1 consists of fan materials derived predominantly from rhyolitic ash flow tuffs. Sub-Area A-2 consists of fan materials derived predominantly from rhyolitic ash flow tuffs and mineralized granitic rocks of the Yerington Batholith; and, to a lesser extent, andesitic lava flows and limestone. The report noted that the distribution of soil types associated with Sub-Area A-1 and Sub-Area A-2 are uncertain beneath OU-4b (BC, 2009b). As described in the *Final Remedial Investigation Report, Evaporation Ponds Operable Unit (OU-4a)* (OU-4a RI) (CEC, 2019), Sub-Area A-1 BCLs are likely the most applicable for OU-4a, however, the presence of a pre-mining playa-like deposit (as shown on the 1938 aerial photograph in Appendix 2B) in the area may have resulted in enrichment of COIs. Therefore, in the OU-4a RI comparison of COIs to Sub-Area A-1 BCLs is a conservative approach, and the background soil concentrations for the depositional environment beneath OU-4a are likely to be higher than the Sub-Area A-1 BCLs (CEC, 2019).

Similar to the rationale provided in the OU-4a RI, the soil beneath OU-4b would be subject to similar pre-mining processes as those described for OU-4a. In addition, the Ground Hog Hills, located southeast of OU-4b, may have been a source of mineralization to pre-mining native soils beneath OU-4b.

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Consequently, the COI concentrations in pre-mining native soils beneath OU-4b may be somewhat higher than COI concentrations in Sub-Area A-1. As a result, while Sub-Area A-1 BCLs are used in the identification of COIs for OU-4b, they also likely represent a conservative approach that is similar to the approach used for OU-4a. Following these observations, the soil analytes identified as COIs and evaluated in the OU-4b RI consist of:

- Metals: antimony, total chromium, copper, iron, magnesium, mercury, molybdenum, selenium, and uranium

- Radionuclides: radium-226 and radium-228 (radium-228 did not meet the criteria of being detected in more than 10% of the sample population, but is retained as a COI at NDEP's request)

These COIs are the focus of the nature and extent of contamination, and the fate and transport evaluations. The selection of these COIs is not intended to replace the screening process in the future Human Health Risk Assessment (HHRA) and Screening Level Ecological Risk Assessment (SLERA). Screening and evaluation of all analytes will be addressed in the future HHRA and SLERA, which will result in the identification of constituents of potential concern (COPCs) and constituents of potential ecological concern (COPECs).

OU-4b Material Types

Several mine-related material types were observed during sampling. VLT was present at the surface of all locations and overlies sulfide tailings. For five of the six deep borehole locations, the sulfide tailings overlie native soil. However, at location STSB-02, the sulfide tailings overlie calcines, which in turn overlie native soil (Figure 4-2). Location STSB-02 is near the western boundary of OU-4b, which is adjacent to the Calcine Ditch. The presence of calcines at the base of the sulfide tailings likely reflects the migration of depositional boundaries of the calcinated sediments through time. Historical aerial photographs in Appendix 2B show the evolution of the Calcine Ditch during mining operations. Prior to the processing of sulfide ore and the creation of the sulfide tailings embankments, it is likely that calcines and oxide process water were discharged over the area that would later be covered with sulfide tailings. There is some uncertainty in the exact extent of calcines beneath OU-4b; however, calcine deposition in OU-4b occurred for a limited time and, for the majority of mining operations, calcines were discharged to the west of OU-4b. Based on the deep borehole information and the historical aerial photographs, calcinated materials are limited to a small percentage of OU-4b in the southwestern portion of the OU. Because only one sample out of the 176 samples collected during the 2019-2020 contained calcines, they are not presented in summary figures or used in statistical comparisons. The one calcine sample is summarized in Table 4-2, and the complete sample results are presented in Appendix 4D.

Metals and Radionuclide Results

Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, antimony, magnesium, iron, total chromium, and radium-228. In terms of COI distribution, some spatial geochemical variability is observed laterally and vertically in OU-4b. The variability seen in OU-4b samples appears to be controlled largely by material type, and by the tailings area (Phase 1 or Phase 2) in which the sample is located, as described further below.

Based on statistical testing, there are consistent differences in several COI concentrations between the sulfide tailings and VLT. Statistically, median values from the VLT for antimony, total chromium, mercury, molybdenum, selenium, radium-226, and radium-228 are all higher than those from the sulfide tailings. COI concentrations of copper, iron, magnesium, and uranium are generally similar between the sulfide tailings and VLT.

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The use of the southern area for process evaporation or recycling ponds may have influenced the distribution of COIs across OU-4b. Based on statistical testing in VLT samples, COI concentrations of total chromium, iron, molybdenum, uranium, and radium-228 were statistically higher in the southern area compared to VLT samples in the northern area. Copper concentrations in VLT samples were statistically lower in the southern area compared to VLT samples in the northern area. With respect to the sulfide tailings, COI concentrations of total chromium, iron, magnesium, and uranium were statistically higher in the southern area compared to sulfide tailings samples in the northern area. Radium-226 concentrations in sulfide tailings samples were statistically lower in the southern area compared to sulfide tailings samples in the northern area.

MWMP Results

The MWMP method is generally used for simulating leaching in a surficial or near-surface waste rock environment and has less of a direct application for the subsurface soil environment. As such, there are limitations to evaluating MWMP results; however, the results provide a general estimate of the relative mobility of COIs from OU-4b materials and will be utilized in the forthcoming screening level risk assessment (SLERA).

Concentrations of COIs were detected in the MWMP extract with magnesium being detected most often followed by uranium, copper, selenium, molybdenum, iron, radium-226, antimony, total chromium, mercury, and radium-228. Magnesium, uranium, selenium, and copper were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples compared to the solid/total samples.

ABA Results

ABA analysis is a method to assist in predicting and assessing the acid generation and neutralization potential of waste rock. ABA consists of multiple analyses, including acid generating potential (AGP), acid neutralization potential (ANP), the neutralization potential ratio (NPR), and the net neutralization potential (NNP). Both NPR and NNP parameters are ways to assess the relative amounts of ANP and AGP and are used in prediction of the likelihood of sulfidic material to become potentially acid generating (PAG).

The Net Acid Generation (NAG) test can be used to potentially resolve uncertainties from the ABA analysis (Stewart, et al., 2006). Using the NAG as a supplement to the NNP suggests that the majority of all samples from all material types are likely non-PAG. In addition, the results are consistent with the classification from the NPR and NNP that suggest that, of the samples that are classified as PAG, the sulfide tailings have the highest number of samples.

When looking at the NPR and NNP, using the NNP alone for PAG classification yields more uncertain results, making PAG classification using NPR or the NNP with NAG a more conservative approach. materials in OU-4b have very limited contact with significant amounts of surface runoff or groundwater, which would limit the amount of or preclude acid generation from the sulfide tailings and VLT.

In general, the sulfide tailings have a greater percentage of samples that can be classified as PAG, compared to VLT samples. From the laboratory analysis, sulfide tailings samples also have higher overall values of AGP. Pyritic sulfur, potentially acid generating sulfur, water soluble sulfate, and total sulfur were also generally detected similarly or more often and at overall higher concentrations in sulfide tailings samples compared to VLT

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OU-4b Fate and Transport

A conceptual site model (CSM) has been prepared which summarizes the routes of transport and the physical nature of OU-4b. This CSM does not include exposure pathways or receptors as those will be developed in the forthcoming risk assessment.

The CSM describes post-process solid materials from sulfide ore beneficiation that were emplaced within the Phase 1 and 2 tailings embankments. The majority of OU-4b is composed of sulfide tailings, along with VLT cover materials. Sulfide tailings were generated during the fine crushing of the sulfide ore during the beneficiation process. After the removal of the copper through a floatation process, the fine-grained tailings were deposited as a slurry in designated areas within the tailings embankments. Following deposition, the tailings were covered with VLT. Because the sulfide tailings and VLT cover materials were generated under extensive, controlled beneficiation processes, these materials generally display a consistent range of concentrations across OU-4b. Subsequent post-emplacement construction of the process evaporation and recycling pond in the southern portion of OU-4b resulted in some spatial variability in COIs between the northern and southern areas of the OU, as described further below.

Based on the recent investigation, the thickness of the mine-related material (VLT, sulfide tailings, and calcines) ranged from approximately 24.5 feet to 68.5 feet. Of the mine-related material, the VLT ranged in thickness from approximately 0.5 to 14.5 feet, and the sulfide tailings ranged in thickness from approximately 19.25 to 65.5 feet. The native soil contact beneath the sulfide tailings generally slopes from the south and southeast to the north and northwest. Generally, VLT thicknesses increase in the northern portion of OU-4b. The vadose zone extends approximately 15 feet beneath the sulfide tailings in the northern portion of OU-4b to approximately 70 feet beneath the sulfide tailings in the southern portion of OU-4b.

The range of concentrations and textures observed in the sulfide tailings are due to natural variability in the composition of the ore, as well as emplacement and post-emplacement processes. Minor variations in texture occurs across the OU, with finer grained sulfide tailings present close to the tailings embankments and farther from historical discharge points. Conversely, less fines are present closer to historical discharge points. However, the finer grained sulfide tailings seen behind the tailings embankments make up less than 5% of the sulfide tailings seen in OU-4b. As such, much of the OU displays a more consistent texture. During mining operations, there were likely variable and migrating discharge locations which resulted in overall lower variability in textures in the tailings impoundments. The presence of process water in the process evaporation or recycling ponds constructed south of the Phase 1 tailings embankments (Section 2.2.1) likely resulted in differing COI concentrations in the VLT and sulfide tailings when comparing the northern and southern areas.

The presence of a pre-mining playa-like deposit in OU-4b may have resulted in enrichment of COIs in native soil. In addition, erosion and deposition from the Ground Hog Hills, located southeast of OU-4b, may have been a source of mineralization to pre-mining native soils beneath OU-4b. Because no discernible downward percolation of precipitation is expected, the source of the concentrations above BCLs in native soil beneath OU-4b are likely a result of these pre-mining conditions. In addition, past mining and mineral processing activities may have affected subsurface soil and may have resulted in MIW that is present beneath OU-4b. Prior to the sulfide ore processing, acidic oxide process water from vat leaching operations as well as calcines were discharged over OU-4b. However, the duration of this discharge was limited, and ceased once the sulfide ore processing took place. The extent of discharge over OU-4b was also limited and appears to be generally confined to the southwestern portion of the OU. In addition, any impacts from the acidic oxide process water would have been neutralized once discharge of the alkaline sulfide tailings began.

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Vertical transport of COIs from OU-4b to the sub-surface is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the sulfide tailings. As described in the OU-1 FRIR, OU-4b was not considered a major source of COIs in groundwater, and migration of groundwater from beneath the sulfide tailings was also not considered significant (CEC, 2020).

OU-5 – Waste Rock Areas Remedial Investigation

The RI information for the South WRA is presented in this section. The RI for W-3 and S-23 has previously been presented in the OU-8 PA RI/FS (Wood, 2020a); the following sections focus on the South WRA. Information from W-3 and S-23 and how they relate to the South WRA are discussed in the main text, as well as a presentation of conclusions related to W-3 and S-23.

Recent OU-5 South WRA Remedial Investigation Summary

The South WRA was sampled in 2019-2020 as part of the investigation described in the Combined FSAP (Wood, 2019). The scope of the investigation consisted of the collection of soil samples from 32 shallow and three deep boreholes drilled in the South WRA. To provide a statistically valid dataset for the RI and risk assessments, soil samples were collected at a total of 35 randomly selected locations from the South WRA. For the shallow boreholes, sampling was performed at four discrete intervals to a total depth of approximately 15 feet bgs. The three deep boreholes were advanced through the waste rock pile to native soil. Once the native soil interface was encountered, boreholes were advanced an additional 20 feet to characterize the vertical and lateral variability of geochemical concentrations as well as potential impacts to the underlying native soil.

OU-5 South WRA Nature and Extent of Contamination

This section presents the nature and extent of contamination for the South WRA, mainly utilizing the data collected from 2018 through 2020. It includes a discussion of COIs, material types, metals and radionuclide results, MWMP results, and ABA results.

Constituents of Interest

The South WRA data were evaluated against BCLs. In this RI, the soil COIs are compared to BCLs as developed in the Background Soils DSR (BC, 2009b). As proposed in the Background Soils DSR, Sub-Area A-2 BCLs are considered the most applicable BCLs to OU-5 (which contains the South WRA). Sub-Area A-2 is in part composed of soils derived from mineralized granitic rocks. The granitic rocks have been subject to large scale alteration and mineralization as evidenced by the several large, known, porphyry copper deposits in the district, including the ACMS ore body. However, comparisons using these BCLs should take into account that the South WRA is composed of alluvial material and waste rock overlying the ACMS ore body; whereas, Sub-Area A-2 is composed only of soil derived from mineralized rock that has been subject to past weathering, erosion, transport and deposition in an alluvial fan system As such, the South WRA would be predisposed to contain higher concentrations of metals because of its proximity to the ACMS ore body and the relatively low amount of weathering that has occurred compared to the Sub-Area A-2 soils. Following these observations, the soil analytes identified as COIs and evaluated in the RI consist of:

- Metals: copper, mercury, molybdenum, selenium, and uranium
- Radionuclides: radium-226 and radium-228 (radium-228 did not meet the criteria of being detected in more than 10% of the sample population, but is retained as a COI at NDEP request)

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These COIs are the focus of the nature and extent of contamination and fate and transport evaluations. The selection of COIs is not intended to replace the screening process in the future HHRA and SLERA. Screening and evaluation of all analytes will be addressed in the future HHRA and SLERA, which will result in the identification of COPCs and COPECs.

South WRA Material Types

The COIs identified in the previous section were used to perform exploratory data analysis (EDA) on the South WRA data. There are likely two types of materials (alluvial material and waste rock) that make up the mine-related material in the South WRA. Unlike the VLT and sulfide tailings seen in OU4b, the South WRA mine-related materials observed during sampling did not lend themselves to visual distinction between alluvium and waste rock. Furthermore, mining of the pit occurred in a multi-step process where during its operational period the pit was expanded to the north (as shown in the aerial photographs in Appendix 2B). As such, alluvial material was excavated at different time periods during mining, causing the South WRA to have alluvial material present inconsistently in different depth intervals and lateral areas. To account for the apparent intermixing of alluvium and waste rock, during the EDA, the possibility of multiple populations was explored in part by using Q-Q plots. Based on the plots, several of the COIs showed a bimodal distribution: copper, molybdenum, selenium, uranium, and radium-226.

Metals and Radionuclide Results

COI concentrations generally do not follow consistent lateral trends throughout the South WRA, which likely is a result of the mechanical placement of the materials during mining operations. The spatial distribution of waste rock and alluvium, and therefore COIs, varies throughout the South WRA. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, and radium-228.

Two-sample hypothesis testing was performed using ProUCL Version 5.1 (U.S. EPA, 2015) to assess vertical trends and COI differences between the four different depth intervals (0 to 0.5, 0.5 to 3, 3 to 6, and 6 to 15 feet bgs) in the upper 15 feet at 35 locations across the South WRA. Based on the testing, the four depth intervals areas have statistically equivalent concentrations of all COIs, suggesting that there is limited variability by depth in the upper 15 feet of the South WRA.

MWMP Results

As previously discussed, MWMP results provide a general estimate of the relative mobility of COIs from South WRA materials and will be utilized in the forthcoming SLERA. Concentrations of COIs were detected in the MWMP extract with uranium and molybdenum being detected most often followed by copper, selenium, radium-226, mercury, and radium-228.

Uranium, molybdenum, and copper were the most often detected COIs in the MWMP samples from the South WRA. These three COIs were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples compared to the total samples.

ABA Results

As described previously ABA analysis is a method to assist in predicting and assessing the acid generation and neutralization potential of waste rock. The NPR and NNP parameters are ways to assess the relative amounts of ANP and AGP and are used in prediction of the likelihood of sulfidic material to become PAG.

Using the NAG as a supplement to the NNP suggests that the majority of all samples from all material types are likely non-PAG. In addition, the results are consistent with the classification from the NPR that

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suggest that no alluvium samples can be classified as PAG, and that less than 10% of waste rock samples can be classified as PAG.

When looking at the NPR, NNP, and NNP with NAG, all methods indicate that the majority of materials in the South WRA are non-PAG. As such, it is likely that South WRA materials will not generate acidic pH values and acidic conditions. The materials in the South WRA have very limited contact with significant amounts of surface runoff or groundwater, which in addition to the non-PAG material classification, would preclude acid generation from the waste rock.

OU-5 South WRA Fate and Transport

A CSM has been prepared which summarizes the routes of transport and the physical nature of the South WRA. The transport mechanisms and pathways in the South WRA are generally consistent with those in W-3 and S-23. This CSM does not include exposure pathways or receptors as those will be developed in the forthcoming risk assessment.

The South WRA is comprised of approximately 90 million tons of alluvial material removed above the ore body and approximately 25 million tons of rock waste generated from removal of the cap rock above the ore (CH2M Hill, 2010). The variability of the source materials resulted in chemical variability in the waste piles, with both waste rock and alluvium showing differing concentrations of COIs. Overall, COI concentrations are lower or similar in the mine-related material in the South WRA compared to W-3 and S-23. However, when looking at the components of the mine-related material, waste rock from the South WRA show similar COI concentrations to the W-3 waste rock.

This CSM for the South WRA describes alluvium and waste rock being delivered to the South WRA and placed in a series of end dumps. Because of this mechanical deposition, and as presented in the analytical results, the COIs do not show consistent trends laterally or with depth. Rather, the concentrations likely represent the variation in the material (waste rock or alluvium) that was being mined and transported to the South WRA as well as the particular area of the pile that the rock was placed at a given time. During mining, waste rock not containing appreciable amounts of copper was generally taken to the South WRA. Low-grade ore was taken to W-3 and S-23, and higher-grade ore was taken to the process area. The exact nature of this segregation process is unknown and may have resulted in some waste rock being delivered to the South WRA that was chemically similar to the waste rock in W-3. Regardless of the process, because of this segregation prior to delivery, a consistent range of COI concentrations occurs within the South WRA. COI concentrations within the South WRA are within one to two orders of magnitude of one another. Additionally, results from 2019-2020 and the 2010 Potential Cover Materials Evaluation (ARC, 2011) are generally consistent with one another, suggesting that the observed ranges in concentrations from the two investigations represent the overall nature of the alluvium and waste rock.

The thickness of the South WRA material ranged from approximately 131.5 feet to 182 feet. The native soil contact beneath the South WRA generally slopes from west to east. There is a large vadose zone of approximately 120 to 200 feet beneath the bottom of the waste rock. As described in Section 5.3.2, only three borings (as specified in the approved Combined FSAP) were advanced into native soil beneath the South WRA. However, because of the thickness of the South WRA material and the underlying vadose zone, there is no exposure pathway to the native soil and groundwater beneath the South WRA, and therefore, the number of native samples to assess nature and extent is considered sufficient.

Transport of COIs away from the South WRA is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. Additionally, the thicknesses of the South WRA, the lack of acid-generating materials, the depth to the groundwater table, and the presence of bedrock beneath the South

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WRA inhibit the transport of COIs to groundwater. The OU-1 FRIR (CEC, 2020) does not consider or describe the South WRA as a past or current source of groundwater contamination.

OU-6 – Oxide Tailings Remedial Investigation

The RI information for OU-6 is presented in this section.

OU-6 Nature and Extent of Contamination

Unlike the 2019-2020 data presented for OU-4b and OU-5, sufficient previous data have been collected to support development of an RI for OU-6, as described in the Combined FSAP (Wood, 2019). Because of this, data evaluated in this OU-6 RI have already been reported in previous documents. This section includes a discussion of COIs, material types, metals and radionuclide results, MWMP results, and ABA results.

Constituents of Interest

The OU-6 data were evaluated against BCLs. In this RI, the soil COIs are compared to BCLs as developed in the Background Soils DSR (BC, 2009b). As proposed in the Background Soils DSR, Sub-Area A-1 BCLs are considered the most applicable BCL to OU-6. From this designation, the soil analytes identified as COIs and evaluated in the RI consist of:

- Metals: antimony, total chromium, copper, magnesium, mercury, molybdenum, and selenium

- Radionuclides: radium-226 and radium-228 (radium-228 did not meet the criteria of being detected in more than 10% of the sample population, but is retained as a COI at NDEP request)

These COIs are the focus of the nature and extent of contamination and fate and transport evaluations. The selection of COIs is not intended to replace the screening process in the future HHRA and SLERA. Screening and evaluation of all analytes will be addressed in the future HHRA and SLERA, which will result in the identification of COPCs and COPECs.

OU-6 Material Types

Unlike other OUs, OU-6 is comprised entirely of VLT. Because of the controlled processes used to create the VLT, there is inherent chemical homogeneity in the material. Chemical homogeneity was observed through several evaluations, as described further in this text.

Based on statistical testing, the shallow (less than 2.5 feet bgs for metals and 6 feet bgs for radium-226) and deep intervals (deeper than 2.5 feet for metals and 6 feet for radium-26) areas have statistically equivalent concentrations of all COIs except radium-228, suggesting that there is limited variability by depth in the upper 25 feet of the VLT. VLT COI concentrations in OU-6 were also compared to the VLT that had been placed as a cover in OU4b, and in general, concentrations of most COIs between the two groups are similar. The similarity between the two groups of VLT further suggests that there is limited variability in the VLT.

Metals and Radionuclide Results

Some spatial geochemical variability is observed laterally in OU-6; however, COI concentrations are generally within one to three orders of magnitude of one another. Of the COIs, radium-226 was most often detected above the BCL followed by copper, mercury, selenium, molybdenum, total chromium, antimony, magnesium, and radium-228.

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In general, COI concentrations are lower in the northwestern portion of the OU. This is the area of the Arimetco, Inc. (Arimetco) Crusher/Hopper and Stacker Area. The area is on the northern margin of the VLT and much of the material in the area may have been excavated and placed in the nearby OU-8 HLP (BC, 2005), leaving a limited amount of VLT at the surface at the time of sampling. As described in Section 6.1.1, limited information on material type exists for samples in these locations; but it is possible that some of the deeper sample intervals could be a combination of VLT and underlying material that was mixed during past excavation activities.

MWMP Results

As previously discussed, MWMP results provide a general estimate of the relative mobility of COIs from South WRA materials and will be utilized in the forthcoming SLERA. Concentrations of COIs were detected in the MWMP extract with copper and magnesium being detected most often followed by selenium, mercury, chromium, antimony, radium-226, molybdenum, and radium-228.

Antimony, copper, magnesium, mercury, and selenium were detected in a similar percentage of samples in both MWMP samples and the total samples. The remaining COIs were detected less often in the MWMP samples compared to the total samples.

ABA Results

As described previously ABA analysis is a method to assist in predicting and assessing the acid generation and neutralization potential of waste rock. The NPR and NNP parameters are ways to assess the relative amounts of ANP and AGP and are used in prediction of the likelihood of sulfidic material to become PAG.

Similar to the VLT in OU-4b, generally, the majority of VLT samples in OU-6 are either non-PAG or in the uncertain range. For the VLT that is classified as PAG, the materials in OU-6 have very limited contact with significant amounts of surface runoff or groundwater, which would limit the amount of or preclude acid generation from the VLT.

OU-6 Fate and Transport

A CSM has been prepared which summarizes the routes of transport and the physical nature of OU-6. This CSM does not include exposure pathways or receptors as those will be developed in the forthcoming risk assessment, and does not include a discussion of VLT in other OUs

OU-6 contains approximately 49 million cubic yards of VLT. The VLT in OU-6 has an average height exceeding 100 feet and an estimated maximum thickness of approximately 190 feet. VLT are the leached products of the vat leach copper extraction process. Because of this controlled process, the VLT is generally chemically homogenous. COIs have a consistent range of concentrations that is likely related to variations in the ore material prior to undergoing the leaching process. The vadose zone beneath the bottom of the VLT ranges from approximately 40 to 130 feet in thickness.

Transport of COIs away from OU-6 is not expected because of the thickness of the VLT, low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. As shown on Figure 6-2, the majority of the VLT is greater than 25 feet thick and given the annual climatic conditions, it is unlikely that the thinner areas of VLT (less than 25 feet thick) present a significant area where percolation to the subsurface soil could occur.

As presented in the OU-1 FRIR, MIW is present beneath OU-6. However, the most likely source of MIW beneath OU-6 is from the HLPs that surround the OU. Groundwater data from the OU-1 FRIR show that COI concentrations are highest beneath the HLPs and decrease beneath OU-6 (CEC, 2020). This conclusion

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is further supported by historical operations information from the OU-8 RI which documented releases of process fluids during HLP operations (CH2M Hill, 2010). The OU-1 FRIR (CEC, 2020) does not consider OU-6 as a past or current source of groundwater contamination.

Risk Assessment

Methods for evaluating the potential for adverse effects to human health and ecological populations will be described in the forthcoming OU-4b, OU-5, and OU-6 human health risk assessment (HHRA) and SLERA work plan. The draft work plan was submitted to the NDEP for review in November 2020 and referenced the information presented in this RI Report. It also provided the crosswalk between the available dataset and its use in risk assessment. The final work plan will be submitted to NDEP after approval of this Final OU-4b, OU-5, and OU-6 RI Report, during Spring 2021.

The OU-4b, OU-5, and OU-6 HHRA and SLERA work plan was developed in accordance with the relevant U.S. EPA guidance with direction from and oversight by the NDEP. The work plan and subsequent HHRA and SLERA report will include standard risk assessment elements including: an OU specific CSM; definition of exposure pathways; methods for selecting constituents of potential concern and of potential ecological concern; exposure and toxicity parameters for evaluation of receptor populations relevant to current and anticipated future conditions within the OUs; and methods for calculation of risk estimates and drawing risk conclusions.

Following approval of the OU-4b, OU-5, and OU-6 HHRA and SLERA work plan, draft and final HHRA and SLERA reports will be prepared and submitted to the NDEP under separate cover.

OU-4b, 5, and 6 Transport Pathways

Based on the results presented in this RI, there are similarities between OU-4b, OU-5, and OU-6 in terms of the potential for transport of COIs from each OU. In general, the pathways relating to transport by water erosion/surface water runoff, leaching/percolation to subsurface soil, and transport to groundwater are incomplete for OU-4b, OU-5, and OU-6.

Future Work

The data sets and evaluation presented in this report adequately describe the nature and extent of COIs in OU-4b, OU-5, and OU-6. Sufficient data have been collected to develop an HHRA and SLERA for the OUs. This report, in conjunction with forthcoming HHRA and SLERA, is sufficient to provide the basis for identifying remedial action objectives and provides the information to develop the Feasibility Study.

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Acronyms and Abbreviations

°F	degrees Fahrenheit
%	percent
2019-2020	Remedial investigation from November 21, 2019 through January 8, 2020
Anaconda	Anaconda Copper Mining Company
ABA	acid-base account
ACMS	Anaconda Copper Mine Site
ACZ	ACZ Laboratories
AGP	acid generating potential
amsl	above mean sea level
ANP	acid neutralization potential
ARC	Atlantic Richfield Company
Arimetco	Arimetco, Inc.
bgs	below ground surface
BC	Brown and Caldwell
BCL	background concentrations limit
BLM	Bureau of Land Management
BMRR	Bureau of Mining Regulation and Reclamation
CEC	Copper Environmental Consulting
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COI	constituent of interest
COPC	constituent of potential concern
COPEC	constituent of potential ecological concern
CV	coefficient of variation
CSM	conceptual site model
DQA	data quality assessment
DQO	data quality objective
DSR	Data Summary Report
EDA	exploratory data analysis
FPXRF	field portable x-ray fluorescence
OU-1 FRIR	Final Remedial Investigation Report, Site-Wide Groundwater Operable Unit (OU-1)
FSAP	field sampling and analysis plan
g	acceleration of gravity
GMS	Groundwater Modeling System
gpm	gallons per minute
H	horizontal
HHRA	Human Health Risk Assessment
HLP	heap leach pad
IAOC	Interim Administration Settlement Agreement and Order on Consent
IQR	interquartile range
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MIW	mine influenced groundwater
mph	miles per hour
MWMP	meteoric water mobility procedure

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MSA	*Remedial Design Materials Screening Assessment* (Ramboll and Arcadis, 2020)
NAG	net acid generation
NDEP	Nevada Division of Environmental Protection
NNP	net neutralization potential
NPR	neutralization potential ratio
OU	operable unit
PA	peripheral area
PAG	potentially acid generating
PAI	Peripheral Area Investigation
PDCI	Pre-Design Component Investigation
pCi/g	picocuries per gram
pCi/L	picocuries per liter
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAC	*Removal Action Characterization*
RD/RA	remedial design/remedial action
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
ROD	record of decision
S-23	S-23 Waste Rock Area
SLERA	Screening Level Ecological Risk Assessment
SOP	standard operating procedure
South WRA	South Waste Rock Area
SOW	Statement of Work
SPS	Singatse Peak Services LLC
SX/EW	solvent extraction/electrowinning
TDS	total dissolved solids
TestAmerica	TestAmerica Laboratories, Inc.
TKN	total Kjeldahl nitrogen
U.S. EPA	U.S. Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
V	vertical
VLT	vat leach tailings
W-3	W-3 Waste Rock Area
Wood	Wood Environment & Infrastructure Solutions, Inc.
WRA	waste rock area
XRF	x-ray fluorescence
YPT	Yerington Paiute Tribe

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1.0   Introduction

On behalf of Atlantic Richfield Company (ARC), Wood Environment & Infrastructure Solutions, Inc. (Wood), has prepared this *Final Combined Operable Unit 4b, 5, and 6 Remedial Investigation Report* for the Anaconda Copper Mine Site (ACMS) in Yerington, Nevada (Figures 1-1 and 1-2). This report was prepared in accordance with the *Interim Administrative Settlement Agreement and Order on Consent* for the ACMS (IAOC) (and the IAOC Appendix B Statement of Work for Site-Wide Remedial Investigation and Feasibility Study [RI/FS SOW]) between the Nevada Division of Environmental Protection (NDEP) and ARC dated February 5, 2018 (NDEP, 2018). The remedial investigation described in this report was conducted in accordance with the *Final Combined Operable Unit4b, Unit-5, and Unit-6 Remedial Investigation Field Sampling and Analysis Plan* (Wood, 2019) approved by NDEP on May 8, 2019 and consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as stated in the National Priorities List Deferral Agreement between the U.S. Environmental Protection Agency (U.S. EPA) and the NDEP (U.S. EPA, 2018). Specifically, the CERCLA-consistent remedial investigation (RI) process complies with sections 121(b) and (d) of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan 40 Code of Federal Regulations (CFR) §§ 300.430(d-f).

ARC received NDEP comments on the draft version of this report (submitted on October 15, 2020) on January 13, 2021. NDEP's comments are addressed in this final version. A response to comments table containing specific responses to NDEP comments is provided in Appendix 1A.

1.1   Contextual Background

This document presents the RIs for Operable Unit (OU) -4b (Sulfide Tailings), OU-5 (Waste Rock Areas), and OU-6 (Oxide Tailings). Originally, the RI/FS SOW grouped OU-2 (Pit Lake), OU-4b, OU-5, and OU-6 together for the purposes of RI characterization activities. However, the RI/FS SOW also stated that the OUs could be separated into different RI Reports as technically appropriate or necessary (NDEP, 2018).

Accordingly, OU-2 has been separated into its own RI Report, as it has different properties and characteristics and the schedule for data collection and evaluation was different from the other OUs. The RI for OU-2 is presented in the *Draft Pit Lake Operable Unit 2 Remedial Investigation Report* (Wood, 2020f).

As described in more detail in Section 2.2.2, OU-5 is composed of three main waste rock areas: W-3 Waste Rock Area (W-3), S-23 Waste Rock area (S-23), and the South Waste Rock Area (South WRA). The RI for W-3 and S-23 was completed previously, as presented in the final *Operable Unit 8 Peripheral Areas Remedial Investigation, Risk Characterization, and Feasibility Study* (OU-8 PA RI/FS) (Wood, 2020a). Evaluation summaries and key conclusions for W-3 and S-23 are included in this report to create a comprehensive description of OU-5.

Shallow groundwater beneath OU-4b, OU-5, and OU-6 has been evaluated in the *Final Remedial Investigation Report, Site-Wide Groundwater Operable Unit (OU-1)* (OU-1 FRIR) (Copper Environmental Consulting [CEC], 2020). Where relevant, groundwater-related findings from the OU-1 FRIR have been included in this report. However, this report is not intended to update or change the conclusions presented in the OU-1 FRIR.

1.2   Purpose of Report

The general objective of an RI is to collect and evaluate sufficient data to characterize the nature and extent of contamination and provide information to support an informed assessment of the potential risk to human health and the environment caused by the release or threatened release of hazardous substances at or from ACMS (U.S. EPA, 1988). The purpose of the RI Report is to summarize data collection activities and the relevant data collected to characterize the OUs. In accordance with the

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guidance for conducting an RI/FS under CERCLA (U.S. EPA, 1988), this RI Report summarizes the results of field activities implemented to identify the potential sources of contamination, characterize the nature and extent of identified contamination, and assess the fate and transport of identified contaminants. The RI also provides and summarizes data available for use in forthcoming human health risk assessments (HHRA) and screening level ecological risk assessments (SLERA).

1.3   Report Organization

This report is comprised of nine sections that generally follow the RI Report outline recommended by U.S. EPA (1988), as follows:

- Section 1: introduction

- Section 2: ACMS description

- Section 3: physical characteristics of the ACMS

- Section 4: investigation summaries and results for OU-4b

- Section 5: investigation summaries and results for OU-5

- Section 6: investigation summaries and results for OU-6

- Section 7: current status and planned activities for risk assessments

- Section 8: summaries and conclusions

- Section 9: cited references

This report also includes the following appendices:

- Appendix 1A, response to comments table for NDEP comments dated January 13, 2021 for the Draft Combined OU-4b-5-6 RI Report

- Appendices: 2A, Groundwater Modeling System (GMS) volume estimation information; and 2B, historical aerial photographs

- Appendices: 4A, data from previous investigations (2010) collected prior to 2019; 4B, Borehole logs from the recent 2019-2020 OU-4b investigation; 4C, summary of the data quality from the recent 2019-2020 OU-4b investigation along with laboratory and validation reports, and a database export; 4D, data tables and a database output for the data collected during the recent 2019-2020 investigation; 4E, ProUCL software output data; and 4F, photographs documenting current conditions of the perimeter of OU-4b.

- Appendices: 5A, data from previous investigations (2010 to 2018) collected prior to 2019; 5B, copy of the previously presented Material Screening Assessment and technical memorandum describing sampling in the oxide tailings also referred to as vat leach tailings (VLT) (OU-6) and South WRA (OU-5); 5C, borehole logs from the recent 2019-2020 OU-4b investigation; 5D, summary of the data quality from the recent 2019-2020 OU-5 investigation along with laboratory and validation reports, and a database export; 5E, data tables and a database output for the data collected during the recent 2019-2020 investigation; 5F, Q-Q plots prepared during data evaluation for the South WRA; 5G, ProUCL software output data; and 5H, photographs documenting current conditions of the perimeter of OU-5.

- Appendices: 6A, data from previous investigations (2005 to 2018) in OU-6; 6B; a database export from the 2018 investigation; 6C, ProUCL software output data; and 6D, photographs documenting current conditions of the perimeter of OU-5.

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2.0   ACMS Description

The ACMS comprises approximately 3,017 acres (4.7 square miles) and includes both the former Anaconda Copper Mining Company (Anaconda) and Arimetco, Inc. (Arimetco) mining and milling operations and ore processing facilities. Former Anaconda mining remnants consist of an inactive open pit, waste rock piles, tailings piles, evaporation ponds, underground utilities, remnant foundations, tanks, and buildings north of Burch Drive. Former Arimetco operations remnants include leached ore heap leach pads (HLPs), evaporation ponds, fluid containment ponds associated with the HLPs, fluid conveyance lines, and the solvent extraction/electrowinning (SX/EW) Process Area south of Burch Drive.

The mined ore contained both copper oxides and copper sulfides. In the Anaconda Process Area, copper precipitate (cement copper) was produced from the oxide ore, and copper (flotation) concentrate was produced from the sulfide ore. Copper concentrates and precipitates were shipped off-Site for smelting. Byproducts of the mining operations were sulfide tailings, VLT, iron, and sulfate-rich acid brine from the oxide ore. Tailings were deposited in large dumps, and process liquids were disposed in evaporation ponds.

The SX/EW Process Area is in OU-8 and is the area where pregnant leach solutions from the HLP were processed by Arimetco using the SX/EW process (Figure 1-2). Most of the equipment and buildings in the process area have been removed or demolished; however, some buildings and foundations remain.

2.1   Mine Operational History

Copper exploration and mining in the area dates to the 1860s. Operations began at the ACMS around 1918 as the Nevada Empire Mine. Anaconda acquired the ACMS in 1941 and conducted mining operations from 1953 through 1977 when Anaconda merged with ARC. In June 1978, ARC terminated mining operations at ACMS, and, in 1982, sold its interests to Don Tibbals, a local resident and former Site employee. In 1989, Arimetco purchased much of the property at the ACMS, excluding the area of Weed Heights. Arimetco utilized an HLP copper recovery operation that used existing ore, waste rock, and tailings stockpiled at the ACMS and imported ore from the MacArthur Pit from 1989 to 2000. Arimetco ceased mining operations in 2000.

2.2   Operable Unit Descriptions

2.2.1   OU-4b – Sulfide Tailings

The sulfide tailings area occupies a total surface area of approximately 600 acres (Figure 2-1). OU-4b is located north and northeast of the OU-3 Process Area, and east of OU-4a and OU-6. The Wabuska Drain (OU-7) originates north of OU-4b.

The estimated volume of mining-related material in OU-4b is approximately 55 million cubic yards. The estimated volume was calculated using a three-dimensional conceptual model with the GMS software package (Aquaveo™, 2017) and OU-4b information described in Section 4.3.2. Additional information on the volume estimation process is presented in Appendix 2A.

In general, the thickness of the mining-related material increases from approximately 15 to 30 feet in the south to approximately 40 to 68 feet to the north. The thickness of the tailings was also estimated using GMS, and details of the volume and thickness estimation process are described in the *Final Combined Operable Unit-4b, Unit-5, and Unit-6 Remedial Investigation Field Sampling and Analysis Plan* (Combined FSAP) (Wood, 2019). Both the tailings volume and thicknesses were updated and supplemented with direct measurements from select boreholes as described later in Section 4.3 of this RI Report.

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The Sulfide Concentrator Plant was constructed in 1961 (CH2M Hill, 2010), along with an initial tailings embankment constructed from VLT that was located in the middle of the current sulfide tailings area (Phase 1 tailings embankment, Figure 2-1). Sulfide tailings were generated from the sulfide ore beneficiation process (i.e., fine crushing and copper sulfide recovery by chemical flotation). The fine crushing of the sulfide ore produced fine-grained material [Brown and Caldwell (BC), 2009a]. The fine-grained tailings were deposited as slurry in designated sections of the tailings impoundment, and decanted water from the tailings area was pumped back into the process circuit. In 1968, a new sulfide tailings embankment was constructed using VLT to allow the impoundment to expand to the north to its current configuration (Phase 2 tailings embankment, Figure 2-1). In 1974, the southern portion of the sulfide tailings area (south of the initial tailings embankment) was subdivided into numerous shallow evaporation or recycling ponds as shown on Figure 2-1 (BC, 2009a). Some of the ponds were used for recycling solutions from the sulfide beneficiation process, while others were used to provide additional storage capacity and evaporation surface area for the spent solutions from the oxide leaching process (BC, 2011b). The area north of the initial tailings dam was apparently used for sulfide tailings only and was not subdivided into smaller ponds. Appendix 2B presents historical aerial photographs which show the mining activities in OU-4b through time.

When mining operations ceased in 1978, approximately 95 percent of the surface of the sulfide tailings was covered with VLT. As part of a removal action conducted in 2006 to address dust concerns, the EPA covered most of the remaining exposed sulfide tailings with VLT (CH2M Hill, 2010). The GMS-estimated 55 million cubic yards of mining-related material in OU-4b consists of approximately 49 million cubic yards of sulfide tailings and approximately 6 million cubic yards of VLT.

In the late 1980s or early 1990s, Arimetco excavated an approximately 500- by 300-feet area of the northern portion of the Sulfide Tailings Area, resulting in an excavation up to 30 feet deep (Arimetco Borrow Pit, Figure 2-1). Arimetco used the sulfide tailings from this excavation to construct the sub-liner base beneath the HLPs (BC, 2009a). Additional shallow excavations and backhoe pits from Arimetco operations are present in the northern portion of the Sulfide Tailings Area and were presumably constructed to search for other borrow areas. Arimetco also excavated an approximately 500-feet long and 20-feet deep trench southwest of the borrow pit, which was used as an on-Site landfill (Figure 2-1). The specific contents and types of wastes discarded in this trench are unknown and have been partially covered. The remaining visible waste appears to be non-hazardous industrial waste and construction materials such as wood pallets, cement bags, and office waste (BC, 2009a). Limited documentation of the landfill is available, however, Arimetco operational documents indicate that the landfill was a permitted Class III, non-hazardous waste landfill. Following the scope work presented in the Combined FSAP (Wood, 2019), information collected during the 2019-2020 investigation was used to assess potential impacts from the landfill, as described further in Section 4.6.

2.2.2   OU-5 – Waste Rock Areas

Three waste rock areas (WRAs) – W-3, S-23, and the South WRA (Figure 1-2) comprise OU-5. The three WRAs have a combined area of approximately 506 acres.

2.2.2.1   W-3

The present-day area of W-3 covers approximately 80 acres, although the size of W-3 has varied through its history. W-3 is present north of the pit (OU-2), south of OU-3 and Burch Drive, and is adjacent to the OU-8 Phase I/II and Phase IV Slot HLPs (Figure 1-2). W-3 is in OU-5 and contains low-grade oxide ore with approximately 0.2 percent (%) to 0.3% copper. The W-3 area was developed by piling excavated material from the open pit beginning in 1953 (BC, 2009a) and expanded in various directions over an

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approximately 25-year period. At its largest extent, W-3 encompassed approximately 170 acres (CH2M Hill, 2010).

Anaconda excavated a portion of W-3 to augment the vat leach operation (CH2M Hill, 2011). The resulting feature became known as the "Slot" (Figure 1-2). The Slot currently is a relatively flat, low-lying feature in between the present-day extents of W-3 and the adjacent Phase IV Slot HLP. Anaconda also operated portions of W-3 as a dump leach system from 1965 to 1968 (CH2M Hill, 2010). Following Anaconda operations, in the 1990s, Arimetco utilized material from W-3 to supply leach materials for the Phase IV Slot HLP.

The current area of W-3, following excavation by Arimetco, covers approximately 80 acres. The W-3 side slopes are generally 1.4 horizontal (H):1 vertical (V) and have a maximum height of approximately 210 feet, although the side slopes may be steeper in terraces located north of the Slot. Materials piled as part of W-3 consist of quartz monzonite with varying degrees of oxide mineralization and range in size from 8 inches in diameter to silt-sized particles (CH2M Hill, 2010). W-3 has been characterized in the OU-8 PA RI/FS (Wood, 2020a).

2.2.2.2   S-23

S-23 is in OU-5 and covers approximately 19 acres. S-23 generally consists of low-grade sulfide ore stockpiled west of the OU-8 Phase I/II HLP and south of the SX/EW Process Area (Figure 1-2). S-23 was originally constructed by Anaconda beginning in 1953 during excavation of the open pit (BC, 2009a) and has been identified on historical maps as "Sulfide Tailings," "Low-grade Sulfide Ore," or "S-23 Waste Rock." The side slopes are generally 1.4 H:1 V and have a maximum height of approximately 110 feet (CH2M Hill, 2010). S-23 has been characterized in the OU-8 PA RI/FS (Wood, 2020a).

2.2.2.3   South Waste Rock Area

The South WRA is the largest of the three WRAs, covering an area of approximately 407 acres. The South WRA is located South of the pit (OU-2) (Figure 2-2). It contains most of the approximately 90 million tons of alluvial material removed above the ore body and another approximately 25 million tons of waste rock that was associated with the ore. The side slopes are generally sloped 1.4H:1V and have a maximum height of approximately 160 feet (CH2M Hill, 2010). Using the GMS software package (Appendix 2A) along with direct measurements presented in Section 5.3.2, the volume of the South WRA is estimated at approximately 73 million cubic yards.

2.2.3   OU-6 – Oxide Tailings

The current extent of the OU-6 area covers approximately 300 acres. OU-6 is located north of the OU-8 Phase III-3X HLP, west of the Calcine Ditch portion of OU-4a, and southwest of the OU-8 Phase IV-VLT HLP (Figure 2-3). The areal extent of VLT across the ACMS is challenging to estimate as VLT has been used at the ACMS as a cover material across multiple OUs, as described further in Section 6.3. The VLT in OU-6 has an average height exceeding 100 feet (CH2M Hill, 2010) and a maximum thickness of approximately 190 feet, as estimated using the GMS software package (Appendix 2A). The side slopes generally range from 1.3H:1V to 1.5H:1V. The top surfaces are composed of multiple benches and VLT mounds. Using the GMS software package, the estimated volume of VLT remaining in OU-6 is approximately 49 million cubic yards.

Oxide tailings, or VLT, are the products of Anaconda's vat leach copper extraction process. The oxide tailings dumps contain the crushed rock and other residual material removed from the leach vats following the extraction of copper by the vat-leaching process (CH2M Hill, 2010). The vat-leach process involved crushing oxide ore into a uniform, minus 0.5-inch size. The crushed ore was loaded into one of

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eight large concrete leach vats in the process area where sulfuric acid was circulated over an 8-day period (CH2M Hill, 2010). Pregnant leach water exiting the vats was conveyed to the precipitation vats, where cement copper was precipitated onto iron and de-tinned cans. Barren water was then passed to iron launders, where excess iron was removed, and the water recycled to the leach vats. Following the 8-day cycle, the spent ore was removed from the vats and transferred to haul trucks for conveyance to the oxide tailings area, where it was reportedly washed out of haul trucks as it was placed. The rate of delivery of oxide tailings was estimated at approximately 10,000 tons per day, beginning in 1953 (CH2M Hill, 2010). The sulfate- and iron-rich water that resulted from this process was discharged to the unlined and lined evaporation ponds (CH2M Hill, 2010).

There are several process area components in OU-6 that were evaluated in the *Process Areas (OU-3) Remedial Investigation Report* (BC, 2016). These components are the Arimetco Acid tanks, located in the northern portion of OU-6, and the Arimetco Crusher/Hopper and Stacker areas, located at the north end of OU-6 (Figure 2-3). These components were used by Arimetco during their operations.

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3.0   Physical Characteristics of the ACMS

This section describes the physical characteristics of the ACMS which includes the OUs in this report. The physical settings of OU-4b, OU-5, and OU-6 are covered in more detail in Sections 4.0 through 6.0, respectively.

3.1   Demographics and Land Use

Lyon County, Nevada, covers approximately 1,993 square miles, and its population in 2013 was 51,585 (U.S. Census Bureau, 2015). Communities near the ACMS include Yerington, Weed Heights, the Yerington Paiute Tribe (YPT) colony, Campbell Ranch Property, and the historic town of Mason. Additionally, the Walker River Paiute Tribe Reservation is located approximately 14 miles to the east of the ACMS, along with the community of Schurz which is located approximately 20 miles to the east of the ACMS. The regional population and industrial centers near ACMS include Fernley (47 miles north), Fallon (59 miles northwest), Hawthorne (57 miles southeast), and Reno (85 miles northwest). Yerington's economic base is primarily agriculture.

Land use in the vicinity of ACMS has included: large-scale mine operations, ranching, agriculture, urban center, YPT colony, Bureau of Land Management (BLM) range land, and residential acreage. In 2000, a total of 88,600 acres of irrigated land was mapped in the Walker River basin. Of this land, 39,100 acres (44%) occurred in Mason Valley (Lopes and Allander, 2009a). Principal agricultural activities in the valley include farming (hay, grain, and onions) and cattle ranching (Lopes and Allander, 2009a; Lopes and Allander, 2009b; Carroll et al., 2010). Irrigation water is provided by surface water diversions from the Walker River and from pumped groundwater.

3.2   Climate

Being situated in the rain shadow of the Sierra Nevada (a very large and tall mountain range west of the ACMS), Nevada is the driest American state with an average annual rainfall of 10.3 inches. January is typically the wettest month. Due to altitude and continental effects, winters are long and cold in the northern part of the state, where Lyon County is located, and summers are warm and arid.

The average annual precipitation is approximately 5.06 inches in Yerington (Desert Research Institute, 2020a), and pan evaporation rates for the region are approximately 69 inches per year (Desert Research Institute, 2020b). The average monthly temperature for the period of record (from March 1, 1894, through June 10, 2016) ranges from a maximum of 92.4 degrees Fahrenheit (°F) in July to a minimum of 17.8°F in January (Desert Research Institute, 2020a).

Wind speed and direction at ACMS vary locally due, in part, to the heterogeneous natural topography (i.e., micro-climates) and topography modified during surface mining operations. Meteorological data collected since 2002 indicate that wind direction is variable at ACMS with no quadrant representing over 50% of the total measurements. However, higher wind speeds (greater than 10 miles per hour) are predominantly towards the northeast (BC, 2009c). In 2019 monthly average wind speeds ranged from 1.5 miles per hour (mph) in November to 3.5 mph in February (Wood, 2020d).

3.3   Topography, Geology, and Soils

ACMS is located on the west side of Mason Valley, a structural basin surrounded by uplifted mountain ranges. Mason Valley is bordered by the Singatse Range to the west, the Desert Mountains to the north, and the Wassuk Range to the east. ACMS is located on the flank of the Singatse Range on an east-facing alluvial fan. The mountain blocks are primarily composed of granitic, metamorphic, and volcanic rocks with minor amounts of semi-consolidated to unconsolidated alluvial fan deposits. The Singatse Range has

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been subject to metals mineralization as evidenced by the large copper porphyry ore deposit at ACMS. A geologic map of the Yerington District that describes these features has been published (Proffett and Dilles, 1984). The Yerington orebody is contained in the Yerington Batholith, a series of Jurassic-age, hydrothermally altered, granodioritic, intrusive rocks that compose the local crystalline basement. The basement rock is exposed in the McLeod Hill region east of ACMS and in the walls of the Yerington Pit. The Yerington Batholith is overlain by a Tertiary volcanic series, which is overlain by Quaternary alluvial and fluvial deposits associated with Basin and Range Geologic Province extension.

Unconsolidated alluvial deposits, derived from erosion of the uplifted Singatse Range mountain block, and alluvial materials, deposited by the Walker River, fill the Mason Valley near ACMS. These unconsolidated deposits, collectively called the valley-fill deposits (Huxel and Harris, 1969), comprise four geologic units: younger alluvium (including the lacustrine deposits of Lake Lahontan), younger fan deposits, older alluvium, and older fan deposits. Lake Lahontan lacustrine deposits appear to have been removed and reworked by the Walker River as it meandered across the valley (Huxel and Harris, 1969). Huxel and Harris estimated that the Pleistocene-age Lake Lahontan in Mason Valley existed for a relatively short time and was less than 60 feet deep.

The geologic setting of the area around ACMS is described in existing literature (Proffett and Dilles, 1984) and additionally by subsurface data obtained by the U.S. Geological Survey (USGS) in 1978 while drilling test wells (i.e., monitoring wells) north of ACMS (Seitz et. al, 1982). Alluvial fan deposits along the west margin of the valley, and stream and lake sediments on the valley floor underlie the tailings and evaporation ponds. The lithology of core samples collected during this RI indicates that the alluvial fan underlying ACMS is generally comprised of fine-grained mudflow deposits and coarser-grained channel deposits.

3.4   Seismicity

The state of Nevada lies within the Basin and Range Geologic Province, one of the most seismically active regions in the United States. Along with California and Alaska, Nevada ranks in the top three states subject to the largest earthquakes over the last 150 years. Three generally north-south trending planar rotation faults transect ACMS (CH2M Hill, 2011), consisting of the Montana-Yerington, Range Front, and Sales Faults.

The most recent seismic activity near ACMS occurred approximately 14.4 miles (23 kilometers) southwest of Smith Valley. Twenty-four small earthquakes within a 31-mile (50-kilometer) radius of ACMS occurred between January 2014 and May 2014, with magnitudes ranging from 1.1 to 2.5 at depths from 1.9 to 14.1 kilometers. The USGS produced maps from an extensive database that provide probabilistic ground accelerations for a given location. The probabilistic seismic hazard at ACMS was obtained from the USGS Earthquake Hazards Program website (USGS, 2020). A 10% probability in 50 years exists for experiencing a peak ground acceleration of 0.24 acceleration of gravity (g) with a recurrence interval of 475 years; a 2% probability in 50 years for experiencing a peak ground acceleration of 0.50 g with a recurrence interval of 2,475 years; and a 1% probability in 50 years for experiencing a peak ground acceleration of 0.66 g with a recurrence interval of 4,975 years.

3.5   Hydrogeology and Groundwater

The alluvial aquifer in the OU-1 Study Area (which extends well beyond the ACMS boundary) is primarily recharged by downward percolation from irrigated fields (49%), leakage from irrigation ditches such as the West and East Campbell Ditches (29%), infiltration from the channel of the Walker River (20%), and infiltration through bedrock of precipitation that falls on surrounding mountain ranges and minor tributary surface flows in ephemeral drainages (2%) (CEC, 2020). The alluvial aquifer within the ACMS

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boundary is in a dead-end, alluvium-filled graben open only on the north to the main alluvial aquifer in the Mason Valley. ACMS is surrounded on three sides by bedrock which outcrops at the surface: the Ground Hog Hills to the east of ACMS, the Singatse Range to the west of ACMS, and a bedrock ridge in the south. Recharge to the alluvial groundwater system beneath ACMS is restricted to infiltration from the Weeds Heights sewage treatment ponds (estimated to be approximately 10 gallons per minute [gpm]) and flow in the bedrock from the Singatse Range into the alluvial valley (estimated to be no more than 3 gpm) (S. S. Papadopulos & Associates, Inc., 2014). Thus, the total recharge to the alluvial system at ACMS is only approximately 13 gpm (CEC, 2020). As a result, groundwater velocities at the Site are low, as discussed in the OU-1 *Evaluation of Plume Stability* (S. S. Papadopulos & Associates, Inc., 2019). Historical groundwater conditions are discussed in Section 4.7.

At the southern end of ACMS, the alluvial aquifer terminates against bedrock, however, the pit (OU-2) in this area is a groundwater depression separated from the northern part of OU-5 by a groundwater flow divide (Wood, 2020f).

Recharge from direct precipitation is negligible (Huxel and Harris, 1969; Lopes and Allander, 2009a and 2009b) because of the low annual average precipitation (5.06 inches per year) at ACMS (Desert Research Institute, 2019a) and high evaporation rates (pan evaporation rates of approximately 69 inches per year) in the region (Desert Research Institute 2019b). Additionally, a Maxey-Eakin analysis of net infiltration and recharge was presented in the *Site-Wide Groundwater Operable Unit (OU-1) Remedial Investigation Work Plan* (BC, 2014). The analysis performed for ACMS and surrounding area showed that groundwater recharge resulting from precipitation in the low-lying portions of the Mason Valley (where ACMS is located) is zero.

Groundwater zone designations for ACMS have been used in previous groundwater related reports that are based on the screen interval elevations of monitoring wells. These designations are:

- Shallow Zone (S): screen intervals that straddle the water table, or are within 50 feet of the water table when a shallower well does not exist, typically greater than 4,300 feet above mean sea level (amsl)

- Intermediate Zone (I): 4,250 to 4,300 feet amsl

- Deep Zone (D): less than 4,250 feet amsl; the Deep zone is further divided into five zones of varying thicknesses.

- Bedrock (B): Wells screened in bedrock regardless of elevation.

The Shallow, Intermediate and Deep zones are all part of the alluvial aquifer which overlies the bedrock.

Depth to groundwater relative to the pre-mining native surface varies across ACMS and the different OUs. For OU-4b, the depth to water ranges from approximately 15 to 70 feet beneath the sulfide tailings generally. For the OU-5 South WRA, the depth to water generally ranges from approximately 120 to 200 feet beneath the waste rock. For OU-6, the depth to water generally ranges from approximately 40 to 130 feet beneath the VLT.

3.6   Ecological Setting and Vegetation

Relative to the ecological setting, much of ACMS has experienced significant disturbance as a result of past mining. Other areas are less severely disturbed and retain areas of sandy soil interspersed with vegetation typical of the sagebrush-steppe mix of shrubs, forbs, and grasses.

The major, natural, aquatic feature near ACMS is the Walker River, which flows north-northeast between ACMS and the town of Yerington. The Walker River flows within 0.25 mile of the southeastern end of

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ACMS. Although riparian systems compose an extremely small fraction of the Great Basin region, they are critical centers of biodiversity; more than 75% of the species in the region are strongly associated with riparian vegetation (Brussard and Dobkin, 2006). The Walker River is typical of Great Basin riparian systems, which are dominated by woody plants, such as cottonwood, aspen, and willow.

Saltbush may be abundant where riverbank soil is saline. The riparian corridor of the Walker River provides habitat for resident and migrating wildlife. The proximity of ACMS to the Walker River likely increases use of ACMS by wildlife. Past activities at ACMS have created aquatic areas that attract wildlife. These areas include the Pit Lake, wastewater treatment ponds, pump-back evaporation ponds, and the lined evaporation and drain-down ponds that seasonally retain water and drain-down solution. These features may provide drinking water for wildlife at ACMS, resting areas for migratory birds, and a source of emergent vegetation for forage and cover for migrating and resident wildlife (CH2M Hill, 2011).

The terrestrial ecosystem near ACMS is characterized by an arid sagebrush-steppe vegetative community that is dominated by sagebrush and other low-lying woody plants interspersed with a variety of forbs and grasses (BC, 2009a).

3.7   Land Ownership and Land Use

Approximately 50 percent of ACMS is privately owned by Singatse Peak Services, LLC (SPS). The remainder is mostly federal land managed by the BLM (Figure 3-1). Current land use activities include draindown-fluids management, routine operations, monitoring and maintenance of wildlife deterrent systems, monitoring and periodic sampling of the groundwater well network, continuing RI/FS-related work, and mineral exploration. No residential or public land use occurs or is permitted on Site.

Various land use controls are in effect to restrict access and certain types of future development. ACMS is fenced, and signage is used to warn against trespassing. Public lands (BLM) at ACMS are closed to all forms of entry by the public under an *Emergency Closure of Federal Lands, Lyon County, Nevada*, published in the Federal Register on April 15, 2005 (authority for the closure is 43 CFR 8364.1).

An Environmental Covenant Agreement was granted by SPS to NDEP and U.S. EPA on February 1, 2017. SPS and NDEP entered into a second Environmental Covenant Agreement on September 11, 2019. Under these agreements (Lyon County Recorder's Office, Document #0562709 and #602394), the use of the SPS-owned property for human habitation or drilling of water wells for consumption or agriculture and certain other activities that could interfere with the remedial action are prohibited. Future arrangements for access and land acquisition will be made with BLM and private landowners in the vicinity of ACMS. As these agreements are finalized, documentation and maps will be revised to reflect changes. ARC will continue to coordinate with representatives from SPS with respect to planned remedial construction on or near SPS-owned land at ACMS.

Current and future adjacent land uses include residential, agricultural, and light industrial and commercial. The closest off-Site residential areas include residences on Luzier Lane, residences on Locust Drive, the Sunset Hills residential area, a trailer park east of ACMS, and the community of Weed Heights. The southern boundary of the YPT and Campbell Ranch Property is located approximately 2.5 miles from the northern boundary of the historical mine property (Figure 1-1). The northern portion of the City of Yerington is east of the historical mine property.

The land ownership of OU-4b, OU-5, and OU-6 is as follows:

- OU-4b – The majority of OU-4b is on BLM land; approximately 40% is on SPS property, and a small portion (less than 5%) in the northeast corner of the OU is on private property associated with the agricultural property north of ACMS.

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- OU-5 – The majority of the South WRA is on BLM land and the remainder (approximately 10%) is on SPS property. The majority of W-3 is on BLM land; the remainder (approximately less than a quarter of the waste rock pile) is on SPS property. All of S-23 is on SPS property.

- OU-6 – The majority of OU-6 is on SPS property, less than 10% is on BLM land, and less than 10% is on private property owned by Don Tibbals.

Land ownership is shown on Figure 3-1.

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4.0   OU-4b – Sulfide Tailings

The RI information for OU-4b is presented in this section. A summary and conclusion of the OU-4b results is presented in Section 4.8, and in discussion with the other OUs in Section 8.0.

4.1   Summary of Previous Investigations

Investigations conducted within OU-4b are described in the following sections. In general, previous (2010 and 2013) data are used for comparison purposes, but most of the data evaluation will be based on the 2019-2020 data set described in Section 4.3 – Recent Remedial Investigation Summary. However, as described further in Section 4.5, all of the previous and recent data are of sufficient quality for use in the RI and forthcoming HHRA and SLERA. Relevant data from the previous investigations are provided in Appendix 4A. The previous investigations consisted of the 2010 Characterization of Potential Cover Materials, the 2010 Sub-Area A Subsurface Characterization, and the 2013 standing rain water opportunistic sampling. The investigations are presented for use in comparisons to more recent data, as described in Section 4.6.

4.1.1   2010 Characterization of Potential Cover Materials

ARC performed an investigation that collected data to support decisions regarding materials that may be used for interim covers and/or the design of final closure caps, and to supplement pre-existing data as documented in the *Revised Data Summary Report for the Characterization of Potential Cover Materials* (Cover Materials DSR) (ARC, 2011). Samples were collected from multiple areas of the ACMS: native alluvium, South WRA, W-3, S-23, oxide tailings, sulfide tailings, and HLP materials. The investigation was conducted under the 2009 version (Version 5.0) of the Quality Assurance Project Plan (QAPP) (Environmental Standards, Inc. and BC, 2009).

Samples were collected from three locations within OU-4b (CM-SUL-01 through -03; Figure 4-1) using a backhoe. As described in Section 2.2.1, a VLT cap was placed over the sulfide tailings when mining operations ceased in 1978, and again in 2006. Sulfide tailings samples were collected over a 5-foot interval below the VLT cap and resulted in sample depths up to 8 feet below ground surface (bgs). Excavation depths varied between 6.5 and 8 feet deep. All samples were submitted for laboratory analysis of plant growth parameters, metals and radionuclides, meteoric water mobility procedure (MWMP) metals and radionuclides, acid-base account/net acid generation (ABA/NAG), and geotechnical properties. The MWMP leachate analysis included the NDEP, Bureau of Mining Regulation and Reclamation Profile II (BMRR Profile II) list of analytes in addition to radionuclides and general chemistry parameters (bicarbonate alkalinity, and total alkalinity).

Results from the sulfide tailings were evaluated for potential use as cover material relative to six categories: metals and radionuclides mean/maximum values, MWMP leachate concentrations less than drinking water Maximum Contaminant Levels (MCLs), acid-generating potential, potential to support plant growth, plant-available moisture storage capacity, and saturated hydraulic conductivity. Relative to the other materials evaluated, the sulfide tailings were most favorable for plant-available moisture storage capacity and were moderately or least favorable for all other categories. The investigation did not provide specific recommendations on which materials are suitable as a cover material.

4.1.2   2010 Sub-Area A Subsurface Characterization

BC performed an investigation in Sub-Area A (Figure 4-1), an approximately 7.2-acre former process water recycling pond in OU-4b, to characterize subsurface conditions in the area (BC, 2011b). Sub-Area A was covered with approximately 18 to 36-inches of VLT during a 2010 removal action (BC, 2011a) to mitigate

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standing water and the generation of fugitive dust from the underlying pond sediments. The investigation was conducted under QAPP Version 5.0.

Following the placement of VLT in Sub-Area A, the subsurface characterization investigation was conducted to:

1. collect geochemical and geotechnical data for the newly installed VLT cover, underlying sulfide tailings, and subjacent native alluvium;

2. evaluate the potential for the VLT materials to impact underlying tailings, vadose zone soils, and alluvial groundwater under anticipated future climatic conditions at ACMS using laboratory analyses of the collected samples and vadose zone modeling; and,

3. install a groundwater monitoring well to monitor potential leachate that may result from the percolation of meteoric water through the tailings-alluvial soil profile.

Four collocated characterization boreholes were drilled at the location ST-A (Figure 4-1). The boreholes were drilled within 6 feet of each other to allow for a sufficient volume of sample to be collected. Six soil samples from the VLT cover, sulfide tailings, and underlying alluvium were collected for laboratory analysis of metals and radionuclides, MWMP for metals and radionuclides, and geotechnical properties. Key findings from the investigation include:

- The thickness of the sulfide tailings and alluvial soils at ST-A are approximately 20 and 15 feet, respectively. The upper 0.5 feet of sulfide tailings consisted of moist-to-saturated pond sediments. These materials were covered with compacted VLT up to 4.75 feet thick. Bedrock was encountered approximately 40 feet below the top of the newly placed cover.

- No groundwater was encountered in the native alluvial soils.

- Screening criteria were exceeded only in solid material samples for chromium, radium-226, and uranium plus daughter products collected from the newly installed VLT cover and from the sulfide tailings; no alluvial soil samples exceeded a screening value.

Even though groundwater was not encountered during the investigation, a "leachate collection well" (ST-A, Figure 4-1) was installed at the borehole location at the base of the alluvial soils. This well is not part of the site-wide groundwater monitoring network as well ST-A has remained consistently dry as described in the investigation summary report (BC, 2011b), and as confirmed in a recent observation in February 2021.

4.1.3   2013 Standing Rain Water Opportunistic Sampling

BC performed an opportunistic surface water collection event conducted in 2013. This event was described in detail in Appendix H of the OU-1 FRIR (CEC, 2020). In summary, there was a 1.55-inch rain event that occurred July 4, 2013. Following the rain event, standing water was observed at numerous locations areas across the ACMS where standing water historically had not been recorded or observed. On July 8, 2013, ARC requested (via e-mail) that the U.S. EPA approve the collection of standing rain water samples for water quality analysis, including tracer data for use in the OU-1 RI. After EPA approved this opportunistic sampling event on July 8, 2013, samples were collected from July 9 through July 11, 2013. Five to seven days had elapsed between the rainfall and the sampling. Figure 4-1 shows the one location (SRW-SAA-1) collected from OU-4b, located in the vicinity of Sub-Area A. The sampling was conducted under QAPP Version 5.0.

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4.2   Preliminary Conceptual Site Model

Information relating to a conceptual site model (CSM) for OU-4b has been presented previously in two documents. A physical CSM was presented in the Combined FSAP (Wood, 2019), and transport pathways have been presented as part of the *Conceptual Site Model for the Yerington Mine Site* (Site-wide CSM) (BC, 2009a). The relevant information from both documents is summarized in the following sections.

4.2.1   Physical Setting

The primary potential source materials in OU-4b are the sulfide tailings and associated VLT cover materials. Potential secondary impacted media are native materials beneath the sulfide tailings and groundwater through infiltration of dissolved phased constituents of interest (COIs). A CSM for these media and potential emplacement and post-emplacement processes that may affect the variability of COIs is described below.

The physical CSM for OU-4b (Wood, 2019) describes post-process solid materials from sulfide ore beneficiation emplaced within the initial and expanded tailings embankments described in Section 2.2.1, the primary volume of sulfide tailings, and VLT cover materials emplaced after 1978. Sulfide tailings were generated during the fine crushing of the sulfide ore during beneficiation After the removal of the copper through a floatation process, the fine-grained tailings were deposited as a slurry in designated areas within the impoundments as described in Section 2.2.1. Because the sulfide tailings and VLT cover materials were generated under extensive, controlled beneficiation, the initial assumption presented in the Combined FSAP was that prior to slurry-emplacement within the impoundment, each material type was distinct physically and chemically homogeneous.

As presented in the Combined FSAP, the tailings and cover materials are a potential source of metals and/or radionuclides. The primary release mechanisms are solid particles released as wind-blown dust and fine sediment transport with storm water runoff.

4.2.2   Potential Transport Pathways

This section addresses the potential transport pathways through which COIs could be dispersed in the environment. The Site-wide CSM included a general discussion of transport mechanisms for the sulfide tailings (BC, 2009a).

In conjunction with the primary release mechanisms described in Section 4.2.1, the transport pathways evaluated for OU-4b consist of the following:

- Transport by water erosion/surface water runoff
- Leaching/percolation to subsurface soil
- Transport to groundwater
- Transport by wind erosion

Each of these potential transport pathways are discussed further in Section 4.7.

4.3   Recent Remedial Investigation Summary

This section describes the Data Quality Objectives (DQOs), and the types of information used to characterize OU-4b, specifically information collected during the recent OU-4b RI performed in 2019-2020. The OU-4b RI was performed in accordance with the approved Combined FSAP (Wood, 2019) and the *Site-Wide Quality Assurance Project Plan, Update Version 5.1* (Site-Wide QAPP) (ARC, 2018). Previous investigations are described in Section 4.1.

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4.3.1   Data Quality Objectives

DQOs for the recent OU-4b RI were developed to facilitate the collection of reliable data for decision-making by the project-management team. A systematic seven-step planning approach was used as outlined in the U.S. EPA quality assurance document *Guidance on Systematic Planning Using the Data Quality Objective Process* (U.S. EPA, 2006). DQOs for the recent OU-4b investigation were originally presented in the Combined FSAP (Wood, 2019). The first two steps (problem statement and goals of the study) are presented here for reference. and have been slightly modified to indicate that sampling has been completed.

4.3.1.1   Step 1: State the Problem

Problem Statement: Chemistry data for materials in OU-4b are not sufficient to define the magnitude or spatial distribution of site-related COI concentrations necessary to support the RI and risk assessments.

4.3.1.2   Step 2: Identify the Goals of the Study

The primary goal of the study is to generate data of acceptable quality on concentrations of COIs in materials placed in OU-4b. The data will be used to complete the RI/FS, which includes conducting assessments of risk to human and ecological receptor populations.

Study Question: Are the lateral and vertical extent of COI concentrations in OU-4b materials sufficiently characterized for the purposes of RI/FS assessment of impacted media, identification of potential physical transport mechanisms, assessment of potential risk to human and ecological receptors, or support evaluation of remedial alternatives?

Alternative outcomes:

1. The lateral and vertical extents of COI concentrations in OU-4b are sufficiently characterized. Additional sampling is not required. RI/FS, risk evaluations, and remedial alternative assessments may proceed.

2. The lateral and vertical extents of COI concentrations in OU-4b are not sufficiently characterized. Additional samples must be collected, analyzed, and evaluated before RI/FS and risk evaluations, or remedial alternative assessments may proceed.

Decision Statement: Using results from previous and recent samples, determine whether representative COI concentrations in the sulfide tailings and cover materials in OU-4b are sufficient to proceed with RI/FS and risk evaluations, or remedial alternative assessments. Dataset sufficiency will be evaluated based on spatial and vertical coverage, comparison to background conditions, and consideration of variability with the COI datasets.

4.3.2   OU-4b Investigation

Materials in and underlying OU-4b were sampled in 2019 through 2020 (2019-2020) as part of the RI described in the Combined FSAP (Wood, 2019). The scope of the investigation consisted of the collection of soil samples from 29 shallow and six deep boreholes. To provide a sufficient and statistically valid dataset for the RI and risk assessments, soil samples were collected at a total of 35 randomly selected locations throughout OU-4b. For the shallow boreholes, sampling was performed at four discrete intervals, described in more detail in Section 4.3.2.2, to a total depth of approximately 15 feet bgs. The six deep borehole locations were advanced through the sulfide tailings to native soil. Once the native soil interface was encountered, boreholes were advanced an additional 20 feet to characterize the vertical and lateral variability of geochemical concentrations as well as potential impacts to the underlying native soil. The total explored depths of the deep boreholes varied and were decided in the field based upon the

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observed contact between the sulfide tailings and underlying native soil. Additional details about the methods and procedures used during the investigation are presented in the following sections.

4.3.2.1 Drilling

Drilling activities began on November 21, 2019 and concluded on January 8, 2020. Borehole locations STSB-01 through STSB-35 were drilled in the Sulfide Tailings as shown on Figure 4-1. Deep boreholes (STSB-01 through STSB-06) were advanced to 48, 73, 89, 84, 81, and 71 feet bgs, respectively. Shallow boreholes (STSB-07 through STSB-35) were advanced to a total depth of approximately 15 feet bgs.

Sonic drilling methods were used for borehole advancement and sampling in accordance with Standard Operating Procedure (SOP) 103 – Drilling, Monitoring Well Installation, and Development. Sonic drilling produces a near continuous core over the entire length of the borehole. Drilling activities were performed by Cascade Drilling, LP of West Sacramento, California. Soil samples were collected using either an approximately 6-inch or 4-inch diameter core barrel. Material collected inside the core barrel was extruded into plastic bags that were tied at one end and given to the field geologist for logging and sampling. Samples were collected from each bagged sample interval at the desired depth. During drilling, each borehole was advanced and temporarily cased to its total depth using approximately 6-inch drill casing as coring activities were being performed. Core barrels and drill casing were decontaminated prior to their use at each borehole location in accordance with SOP 201 – Equipment Decontamination.

The boreholes were continuously logged and described using the Unified Soil Classification System (USCS) (ASTM International, 2009) in accordance with SOP – 305 Field Classification of Soil. Borehole logs are presented in Appendix 4B, along with representative core photographs of the materials encountered during drilling, and approximate surface elevations. As described further in Section 4.6.2, in general there were three material types observed during drilling: VLT, sulfide tailings, and native soil. Calcines, the byproduct of the former acid plant typically found in the Calcine Ditch in OU-4a were encountered in one borehole but comprised less than 1% of the materials observed during drilling. Details of the three main material types are as follows:

- **VLT** – VLT comprised approximately 15% of the materials encountered during drilling and was always the first material encountered (i.e., VLT was present at the surface at each borehole location and was always stratigraphically above the underlying sulfide tailings). Over 95% of the VLT encountered was described as a poorly graded gravel with sand, and the remaining VLT was described as a poorly graded sand with gravel. Of these descriptions, the poorly graded gravels with sand were comprised of approximately 55% to 65% gravel, 30% to 40% sand, and 5% fines. The poorly graded sands with gravel were comprised of approximately 60% sand, 35% gravel, and 5% fines.

- **Sulfide Tailings** – Sulfide tailings comprised approximately 70% of the material encountered during drilling. Approximately 55% of the sulfide tailings were described as a silty sand, 40% were described as a poorly graded sand, and less than 5% were described as a lean clay. Of these descriptions, the silty sands were comprised of approximately 60% to 85% sand, 15% to 35% fines, and 0% to 5% gravel. The poorly graded sands were comprised of approximately 70% to 100% sand, 0% to 25% gravel, and 0% to 15% fines. The lean clays were comprised of approximately 60% to 100% fines and 0% to 40% sand.

- **Native Soil** – Native soil comprised approximately 15% of the materials encountered during drilling. Over 90% of the native soil encountered was described as a poorly graded sand, and the remaining native soil was described as a lean clay. Of these descriptions, the poorly graded sands were comprised of approximately 80% to 95% sand, 0% to 15% gravel, and 0% to 5% fines. The lean clays were comprised of approximately 90% to 95% fines and 5% to 10% sand.

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Samples were transferred into a combination of laboratory-supplied sample containers, zip top bags, and 2-gallon plastic buckets, depending on the analytical requirements at each sampling interval. Sample collection is further described in the following section and was performed in accordance with SOP 304 – Soil Sampling. Drill core remaining after sample collection was placed into labeled core boxes and photographed. After drilling, shallow boreholes were backfilled with hydrated bentonite chips. The deep boreholes were backfilled with bentonite cement grout to approximately 40 feet above the total depth followed by hydrated bentonite chips to ground surface. The procedures for backfilling were developed after discussion with the NDEP about borehole plugging requirements at the ACMS and were in general accordance with SOP 104 – Borehole and Monitoring Well Plugging.

4.3.2.2   Sampling

As described in the Combined FSAP (Wood, 2019), all samples collected from the shallow boreholes (STSB-07 through STSB-35) and the uppermost 15 feet of the deep boreholes (STSB-01 through STSB-06) were collected from four depths:

- a discrete sample from approximately 0 to 0.5 feet bgs;

- a composite sample from approximately 0.5 to 3 feet bgs;

- a composite sample from approximately 3 to 6 feet bgs;

- and a composite sample from approximately 6 to 15 feet bgs.

At the deep boreholes, additional composite samples were collected over approximately 10-feet intervals below 15 feet to the depth of the native soil interface. Two samples were collected in the underlying native soil at 5 to 10 feet and 15 to 20 feet beneath the native soil interface. Sampling depths and the number of samples collected within the deep boreholes were decided in the field based upon the observed contact between the sulfide tailings and the underlying alluvium. Sample intervals are shown on the borehole logs presented in Appendix 4B. Prior to being placed in sample containers, the material to be sampled was homogenized then placed in the appropriate sample container in accordance with SOP 304 – Soil Sampling.

Because of adverse weather conditions (snow falling on sampling equipment and freezing of decontamination supplies), for three samples only a partial decontamination was completed. The data quality of these three samples are specifically discussed further in the data quality assessment in Section 4.5.2.

4.3.2.3   Laboratory Analysis

After collection, samples were labeled, and either placed into an ice-cooled chest or other containers as appropriate for the analytical method and transported to the laboratory under chain-of-custody protocol.

All samples collected from OU-4b were analyzed for the following parameters:

- Metals[1] analysis by TestAmerica Laboratories, Inc. (TestAmerica) of Irvine, California

- Radionuclides (radium-226 and radium-228) analysis by TestAmerica of St. Louis, Missouri

Samples collected from a subset of depths were analyzed for the following parameters:

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[1] Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorous, potassium, selenium, silver, sodium, strontium, thallium, thorium, tin, titanium, uranium, vanadium, and zinc.

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- ABA/NAG analysis by ACZ Laboratories of Steamboat Springs, Colorado (ACZ)

- MWMP extraction, and analysis of the MWMP extract for metals, anions (chloride, fluoride, nitrate and nitrite (as N), and sulfate), total Kjeldahl nitrogen (TKN) (as N), total dissolved solids (TDS), pH, weak acid dissociable cyanide, alkalinity, and radium-226 and radium-228) by ACZ

Table 4-1 presents the analytes and analytical methods from the investigation.

4.3.2.4   Data Quality Summary Report

The Quality Assurance / Quality Control (QA/QC) program presented in the Site-Wide QAPP outlines the field and laboratory QA/QC measures for obtaining data, which includes adhering to acceptable test methods and SOPs, following chain-of-custody protocols, collecting of field QC samples at the required frequency, evaluating QC samples for precision and accuracy of field and laboratory methods, and completing data review processes.

Appendix 4C contains the Data Quality Summary Report (Appendix 4C-1) which includes the outcome for data usability, results of field quality control samples, and data validation findings for OU-4b. The Data Quality Summary Report concludes that more than 99 percent of the planned data were completed and deemed available for use as quantitative data. Laboratory analytical reports are provided in Appendix 4C-2. Data validation reports prepared by the third-party data quality reviewer, Environmental Standards, Inc., for chemical results are provided in Appendix 4C-3. A database output of the 2019-2020 data is provided in Appendix 4C-4.

4.4   Stratigraphy and Hydrogeology

Stratigraphic and hydrogeologic information specific to OU-4b are presented here and are in support of the discussion of transport pathways provided in Section 4.7.2. Figures 4-2 and 4-3 show the OU-4b lithology based on the recent 2019-2020 investigation, as well as monitoring well B/W-37 which is a part of the ACMS site-wide monitoring well network. From the recent investigation described in Section 4.3.2, the thickness of the mine-related material (VLT, sulfide tailings, and calcines) ranged from approximately 24.5 feet to 68.5 feet. Of the mine-related material, the VLT ranged in thickness from approximately 0.5 to 14.5 feet, and the sulfide tailings ranged in thickness from 19.25 to 65.5 feet. The native soil contact beneath the sulfide tailings generally slopes from the south and southeast to the north and northwest. Generally, VLT thicknesses increase in the northern portion of OU-4b. Figure 4-4 shows VLT thicknesses across OU-4b.

For the sulfide tailings, there are some variations in the amount of sand and fines within each borehole; however, grain sizes and textures are generally consistent throughout OU-4b. Where variations do occur, they are generally related to distance from the Phase 1 and 2 tailings embankments. For example, behind the Phase 1 tailings embankment, locations STSB-03 and STSB-21 (Figure 4-1) contain relatively thin (2 feet or less) layers of clay-sized tailings interbedded in the surrounding sandier sulfide tailings material. Conversely, less fines are present further to the south, i.e., away from the Phase 1 tailings embankment, per observations at locations STSB-07 and STSB-08. Behind the Phase 2 tailings embankment, locations STSB-04, STSB-05, STSB-06, STSB-28, STSB-32, and STSB-34 also contain similar clay-dominated layers. Similar to the Phase 1 tailings embankment, less fines are present further from the Phase 2 tailings embankment, per observations at locations STSB-22, STSB-23, and STSB-26 (Figure 4-1). These differences suggest that during placement of sulfide tailings, finer grained material would occasionally settle out behind the embankments before being overlain by the more typical coarser sulfide tailings seen elsewhere in OU-4b, and that fines would tend to settle out further from the historical discharge points. The change between finer and coarser material at individual borehole locations also suggests that the discharge points and sulfide deposition varied throughout placement of sulfide tailings.

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Groundwater beneath OU-4b occurs in native soil, not tailings. The 2019 shallow groundwater levels beneath the tailings (UW-1S, B/W-29S, B/W-36S, B/W-37S, B/W-38RS, B/W-76S) ranged from 66.89 to 106.2 feet bgs (Wood, 2020d). The monitoring well locations are shown on Figure 4-1. Groundwater under OU-4b generally flows to the west and to the southwest, with groundwater flow in the northern part of the OU being affected by irrigation practices north of ACMS as described in the OU-1 FRIR. OU-4b is almost entirely underlain by the Shallow Zone (as defined in the OU-1 FRIR) beneath ACMS, except on the southeastern edge of the OU where the alluvial aquifer abuts against bedrock.

The top of the native soil beneath the sulfide tailings ranges from approximately 4,351 feet amsl to 4,413 feet amsl. In 2019, shallow groundwater elevations beneath the tailings ranged from approximately 4,336.12 feet amsl to 4,343.16 feet amsl. When comparing native soil elevations in the same vicinity as underlying groundwater elevations, the vadose zone extends approximately 15 feet beneath the sulfide tailings in the northern portion of OU-4b to approximately 70 feet beneath the sulfide tailings in the southern portion of OU-4b.

4.5   Data Quality Assessment

An assessment of data quality is provided in this section, for the data collected in 2010 and 2013, as well as the data from the 2019-2020 investigation.

4.5.1   2010 and 2013 Investigations

2010 soil data and 2013 standing rain water data have been reported previously as presented in Section 4.1. The 2010 and 2013 data presented in this RI are supported by U.S. EPA approved Site work plans and/or QAPP documents, rigorous sampling and analysis procedures, QA/QC protocols, and documentation requirements.

DQOs for the 2010 characterization of potential cover materials investigation are presented in the *Cover Materials Characterization Work Plan, Revision 2* (Cover Materials Work Plan) (BC, 2010b). Data quality for the 2010 cover materials data (Section 4.1.1) were originally presented in the Cover Materials DSR (ARC, 2011). As presented in the report, sample results met the DQOs and all data are considered usable.

Investigation objectives for the Sub-Area A subsurface characterization are presented in the *Implementation Work Plan - Revision 3, Anaconda Evaporation Pond Removal Action (Thumb Pond and Sub-Area A)* (BC, 2010a). Data quality for the 2010 Sub-Area A investigation were originally presented in the *Sub-Area A Sub-Surface Characterization Data Summary Report* (BC, 2011b). As presented in the report, the geochemical data achieved the DQOs and all data is considered usable.

Because of the opportunistic nature of the 2013 standing rain water sampling, no work plan or DQOs exist for the investigation. However, the sampling was approved by the U.S. EPA as described in Section 4.1.3, and the sample collection procedures followed QAPP requirements.

In summary, all laboratory data from 2010 met the DQOs and QAPP requirements and the 2013 data were collected under the QAPP requirements in place at the time. These data are considered usable for this RI and the forthcoming HHRA and SLERA.

4.5.2   2019-2020 Investigation

This section describes the Data Quality Assessment (DQA) performed for the data collected in OU-4b in 2019-2020 (locations STSB-01 through STSB-35). Because the 2019-2020 data comprise the main dataset used in the remainder of this RI, the DQA presented here includes both a qualitative and quantitative evaluation of the data to determine if the data are of the right type, quality, and quantity to support the study decisions. The DQA provides an assessment of the data usability, determines if the data set is

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complete, and decides whether the data can be used to support characterization of the nature and extent of COIs, risk assessments, and other evaluations.

This DQA is performed on an iterative basis as planned data become available (i.e., after sample collection and analytical data quality control reviews are complete) to determine whether the project-specific DQOs are satisfied. The DQA consists of five steps that relate the quality of the results to the intended use of the data (U.S. EPA, 2006). The five steps of the DQA process are:

- Step 1: Review of DQOs and Sampling Design
- Step 2: Conduct a Preliminary Data Review
- Step 3: Select the Statistical Method
- Step 4: Verify the Assumptions of the Statistical Method
- Step 5: Draw Conclusions from the Data.

The status of the data quality assessment for OU-4b in relation to the five steps in the DQA process is summarized in the following sections.

4.5.2.1 Step 1: Review of DQOs and Sampling Design

This step in the DQA process was completed through the review of DQOs developed for OU-4b. The Combined FSAP (Wood, 2019) presented DQOs for OU-4b, which are also summarized in Section 4.3.1. As demonstrated in this document, the DQOs were met for OU-4b. The overall project objectives for OU-4b were to collect additional characterization data needed to sufficiently characterize OU-4b and evaluate risk to human health and ecological receptors.

4.5.2.2 Step 2: Preliminary Data Review

This step included the review of quality assurance reports for the validation of data, the calculation of basic statistics using the data, and the evaluation of data using graphical techniques. Data evaluated in this document are supported by work plans, rigorous sampling and analysis procedures, QA/QC protocols, and documentation requirements.

Data quality results for OU-4b are presented in Section 4.3.2.4. In general, the OU-4b data presented in this document were deemed acceptable for evaluation. Additional evaluation was performed on the three samples (STSB02_25-35, STSB05_15-25, and STSB05_35-45) potentially affected by the inclement weather-affected decontamination procedures, described in Section 4.3.2.2. Concentrations from these samples, as well as from the samples immediately above and below were reviewed and compared with the corresponding sample intervals in other boreholes that had undergone normal decontamination procedures. No apparent impacts or differences were seen in these samples as compared to other samples where the full decontaminated procedures were achieved. Sample results are provided in Appendix 4D. As a result, the samples in question were retained for evaluation and treated the same as the others.

The following assumptions were applied when using qualified data for the evaluation of chemical data:

- Estimated values were retained and used as reported for the analysis of the spatial distribution of various sampling results on maps, cross sections, and other report graphics. Laboratory results reported as non-detect were represented at the non-detect value for these spatial analyses.
- Only results from primary samples were used for the presentation and evaluation of chemical data. Results for field duplicate samples are retained in the database, but they were not used

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during data evaluation in compliance with the QAPP. An evaluation of field duplicate samples is presented in the DQSR in Appendix 4C-1.

For the OU-4b data, another component of the preliminary data review is exploratory data analysis of certain chemistry parameters. The approach varies based on the type of data collected, but it typically includes tabulating and plotting the data, performing statistical tests to evaluate if the data represent one or more populations, and calculating descriptive statistics. All the available OU-4b data were found valid for use in these preliminary data review methods as discussed in the sections below. Tabulated summary statistics and graphical presentation of the data are provided in Section 4.6.

4.5.2.3 Step 3: Select the Statistical Method

OU-4b data were used to make comparisons of metal concentrations between the depth intervals and material types. The ProUCL Version 5.1 (U.S. EPA, 2015) Goodness-of-Fit test was used to evaluate the population distribution of metals data for OU-4b. The analytical data used for testing are provided in Appendix 4D. The best fit distribution varied by metal and by material type with some of the metals following no distribution. Therefore, when comparing data populations and conducting hypothesis tests, a non-parametric test (Gehan or Wilcoxon-Mann-Whitney test) that does not assume a statistically significant distribution was used. For results reported as non-detect, these statistical methods used the non-detect value in the calculation.

4.5.2.4 Step 4: Verify the Assumptions of the Statistical Method

A key assumption when using parametric statistical tests is that the data follow a normal distribution. Data from OU-4b are summarized in Tables 4-2 through 4-5 and are presented in their entirety in Appendix 4D. Parametric tests have a greater difficulty dealing with outliers and non-detects than their nonparametric counterparts. As stated in the previous section, much of the metals data did not follow a normal distribution; therefore, nonparametric tests were employed for hypothesis testing. Another key assumption for both parametric and nonparametric tests is data independence. Two departures from data independence are commonly encountered: serial patterns in data collection (autocorrelation) and clustering (clumping) of data. Based on the random sampling approach in the grid sampling design presented in the Combined FSAP (Wood, 2019), autocorrelation and clustering were not expected to occur. The assumptions of the statistical tests used are met; therefore, the tests are appropriate for evaluating the data.

4.5.2.5 Step 5: Draw Conclusions from the Data

Section 4.6 presents an overview of the analytical results for OU-4b, including tabulated summary statistics. Conclusions drawn from the data, including those based on statistical hypothesis testing, are presented in Sections 4.6 and 4.8.

4.5.2.6 Data Quality Summary

The data set evaluated in this document is of adequate quality for the intended purpose defined in the DQOs and is acceptable for use in this RI and the forthcoming HHRA and SLERA. Exploratory data analysis indicated the data were not normally distributed; therefore, nonparametric statistical tests were used to evaluate the data. The assumptions of the hypothesis tests were verified, and the conclusions drawn from those tests are discussed in Sections 4.6 and 4.8.

DQOs were established in the Combined FSAP (Wood, 2019) and have been presented again in Section 4.3.1. The problem statements identified the need for additional characterization data, which has been collected as described in Section 4.3.2. Section 4.6 describes how these data adequately characterize

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the nature and extent of contamination. Additionally, Section 4.7 describes the characterization related to contaminant fate and transport. As a result of this presentation and evaluation, the DQOs established in the Combined FSAP (Wood, 2019) have been met.

4.6 Nature and Extent of Contamination

This section presents the nature and extent of contamination for OU-4b, mainly utilizing the data collected in 2019-2020, although the 2010 cover materials and Sub-Area A investigation datasets are also used for comparative purposes.

4.6.1 Constituents of Interest

The samples from OU-4b were analyzed for various analytes as specified in the approved Combined FSAP (Wood, 2019). Although all data are presented in this RI (Appendix 4D), a subset of the analytes is used to focus the discussion of nature and extent, and fate and transport of contaminants. The subset of analytes is referred to as COIs in this report, which were selected to allow for a concise discussion of the general trends seen in the data. The selection of this subset is not intended to replace the screening process in the future HHRA and SLERA. Screening and evaluation of all analytes will be addressed in the future HHRA and SLERA, which will result in the identification of constituents of potential concern (COPCs) and constituents of potential ecological concern (COPECs).

The OU-4b data were evaluated against background concentration limits (BCLs). In this RI, the soil COIs are compared to BCLs as developed in the *Background Soils Data Summary Report* (Background Soils DSR) (BC, 2009b). The Background Soils DSR developed BCLs for two different soil types, designated Sub-Area A-1 and Sub-Area A-2 (note that these sub-areas are different than the Sub-Area A described in Section 4.1.2). Sub-Area A-1 consists of fan materials derived predominantly from rhyolitic ash flow tuffs. Sub-Area A-2 consists of fan materials derived predominantly from rhyolitic ash flow tuffs and mineralized granitic rocks of the Yerington Batholith, and to a lesser extent, andesitic lava flows and limestone. The report noted that the distribution of soil types associated with Sub-Area A-1 and Sub-Area A-2 are uncertain beneath OU-4b (BC, 2009b). As described in the *Final Remedial Investigation Report, Evaporation Ponds Operable Unit (OU-4a)* (OU-4a RI) (CEC, 2019), Sub-Area A-1 BCLs are likely the most applicable for OU-4a; however, the presence of a pre-mining playa-like deposit (as shown on the 1938 aerial photograph in Appendix 2B) in the area may have resulted in enrichment of COIs. Therefore, the OU-4a RI comparison of COIs to Sub-Area A-1 BCLs is a conservative approach, and the background soil concentrations for the depositional environment beneath OU-4a are likely to be higher than the Sub-Area A-1 BCLs (CEC, 2019). Similar to the rationale provided in the OU-4a RI, the soil beneath OU-4b would be subject to similar pre-mining processes as those described for OU-4a. In addition, the Ground Hog Hills, located southeast of OU-4b, may have been a source of mineralization to pre-mining native soils beneath OU-4b. Consequently, the COI concentrations in pre-mining native soils beneath OU-4b may be somewhat higher than COI concentrations in Sub-Area A-1. As a result, while Sub-Area A-1 BCLs are used in the identification of COIs for OU-4b, they also likely represent a conservative approach that is similar to the approach used for OU-4a.

The COIs identified and evaluated were based on elevated concentrations of analytes that were above the respective BCLs following these criteria:

- Analytes detected above their respective BCL in more than 10% of the sample population were retained as COIs. The cutoff value of 10% was chosen after reviewing the data and using professional judgement so that the evaluation could be focused on those analytes that more regularly exceeded their respective BCL.

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- Analytes detected above their respective BCL in less than 10% of the sample population were not retained as COIs

- Analytes that were not detected in any sample above the laboratory reporting limit were not retained as COIs

- Analytes with no BCL (lithium, phosphorus, strontium, tin, and titanium) were not retained as COIs

Following these criteria, the soil analytes identified as COIs and evaluated in the RI consist of:

- Metals: antimony, total chromium, copper, iron, magnesium, mercury, molybdenum, selenium, and uranium

- Radionuclides: radium-226 and radium-228 (radium-228 did not meet the criteria of being detected in more than 10% of the sample population, but is retained as a COI at NDEP's request)

The COIs identified in this section are the focus of the nature and extent of contamination, and the fate and transport evaluations in this section and in Section 4.7, respectively. The discussions of these COIs are supported by map view and cross-sections presented in figures referenced throughout the following sections.

4.6.2   OU-4b Material Types

Several mine-related material types were observed during sampling. VLT was present at the surface of all locations and overlies sulfide tailings. For five of the six deep borehole locations, the sulfide tailings overlaid native soil. However, at location STSB-02, the sulfide tailings overlie calcines, which in turn overlie native soil (Figure 4-2). Location STSB-02 is near the western boundary of OU-4b, which is adjacent to the Calcine Ditch. The presence of calcines at the base of the sulfide tailings likely reflects the migration of depositional boundaries of the calcinated sediments through time. Historical aerial photographs in Appendix 2B show the evolution of the Calcine Ditch during mining operations. Prior to the processing of sulfide ore and the creation of the sulfide tailings embankments, it is likely that calcines and oxide process water were discharged over the area that would later be covered with sulfide tailings. There is some uncertainty in the exact extent of calcines beneath OU-4b; however, calcine deposition in OU-4b occurred for a limited time and, for the majority of mining operations, calcines were discharged to the west of OU-4b. Based on the deep borehole information and the historical aerial photographs, calcinated materials are limited to a small percentage of OU-4b in the southwestern portion of the OU. Because only one sample out of the 176 samples collected during the 2019-2020 contained calcines, they are not presented in summary figures or used in statistical comparisons. The one calcine sample is summarized in Table 4-2, and the complete sample results are presented in Appendix 4D.

Box plots (Figures 4-5 through 4-10) for the COIs were prepared for the three main material types observed during sampling (VLT, sulfide tailings, and native soil). In addition, the box plots include the samples which contained a mixture of sulfide tailings and VLT. These mixed samples are discussed with COIs in the following section. From this classification, approximately 50% of the mine-related material samples are classified as sulfide tailings, 35% as VLT, and 15% as mixed sulfide tailings/VLT. As described above and in Section 4.3.2.1, the calcines made up less than 1% of the materials encountered during drilling and are not included in the box plots or in further discussions of the three main material types.

The interquartile range (IQR) and coefficient of variation (CV) were also used to assess variability in the different material types. The IQR and CV are a measure of dispersion of a dataset's distribution. The IQR is defined as the difference between the 75th and 25th percentiles and are the bounds of the boxes presented in box plots. The CV is defined as the ratio of standard deviation to the mean for the dataset, such that the CV describes the variability of a dataset relative to the mean of the dataset. As described in

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Section 4.5.2, COI concentrations generally did not follow a normal distribution, including when the data were separated by material type. This suggests that the IQR, which is not dependent on the mean, can be an appropriate measure for assessing variability in the different material types. While the CV is relative to the mean rather than the median, it can still be used as a supporting evaluation, while recognizing there may be some uncertainty in its use. When looking at the IQR and CV, some variability is present in COI concentrations. With respect to the IQR in general, material type IQR values for most COIs are similar or less than IQR values for all material types combined. Similarly, the CVs for each material type are generally less than the CV when all the materials are combined (Table 4-2). Both the IQR and CV suggest that there is lower data variability within each material type; and that it is appropriate to evaluate the material types separately.

4.6.3   Metals and Radionuclide Results

Table 4-2 summarizes metal and radionuclide in soil statistics for the OU-4b COIs. Table 4-2 presents statistics for all of the samples and material types combined together, as well as statistics separated by material type, VLT, sulfide tailings, mixed sulfide tailings/VLT, calcines, and native soil, as described in Section 4.6.2. The tables provide: 1) the number of observations, detections, detection frequency, minimum, maximum, mean, median, CV, 25th percentile, 75th percentile, and IQR of all analyzed metals and radionuclides; 2) corresponding Sub-Area A-1 BCLs as described in Section 4.6.1; and 3) percent of observations that exceed these BCLs. A summary of COIs for OU-4b are described in more detail below. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, antimony, magnesium, iron, total chromium, and radium-228.

Some spatial geochemical variability is observed laterally and vertically in OU-4b. The variability seen in OU-4b samples appears to be controlled largely by material type, and by the tailings area (Phase 1 or Phase 2, Section 2.2.1) in which the sample is located, as described further below.

Within the sulfide tailings, samples containing the layers of finer grained material described in Section 4.4 generally had COI concentrations that were consistent with samples that did not have the finer grained material. Iron concentrations from sulfide tailings samples containing the finer grained material were slightly higher than those that did not have the finer grained material. Because only one COI showed a slight difference in concentrations, and that samples containing the finer grained material make up only 5% of the total numbers of samples collected, these samples are not addressed in the remainder of this section.

4.6.3.1   Sample Hypothesis Testing

Two-sample hypothesis testing was performed using ProUCL Version 5.1 (U.S. EPA, 2015) to assess COI differences between several different groupings, either by material type, depth, or geographic position as follows:

- **Testing by material** – Statistical testing was performed by material type to assess the relationships between the sulfide tailings and VLT. Based on the testing, there are consistent differences in several COI concentrations between the sulfide tailings and VLT. Statistically, median values from the VLT for antimony, total chromium, mercury, molybdenum, selenium, radium-226, and radium-228 are all higher than those from the sulfide tailings. COI concentrations of copper, iron, magnesium, and uranium are generally similar between the sulfide tailings and VLT. The results of the statistical testing are shown on Table 4-6, and box plots showing the differences in the material types are shown on Figures 4-5 through 4-10.

- **Testing by depth** – Statistical testing was performed to assess the relationships between the different depth intervals (0 to 0.5, 0.5 to 3, 3 to 6, and 6 to 15 feet bgs) in the upper 15 feet at

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locations STSB-01 though STSB-35. Based on the testing, the trends by depth were less clear than those by material type, suggesting that while there are statistical differences by depth in the upper 15 feet, these overlap with differences by material type. Because VLT overlies the sulfide tailings, for many COIs the concentrations decrease with depth; however, this is likely due to the differences in material type. The results of the statistical testing are shown on Table 4-7.

- **Testing by geographic position** – Statistical testing was performed to assess the relationships between samples behind the Phase 1 tailings embankment (southern area), and those behind the Phase 2 tailings embankment (northern area). As described in Section 4.2.1, the use of the southern area for process evaporation or recycling ponds may have influenced the distribution of COIs across OU-4b. Based on the testing, in VLT samples COI concentrations of total chromium, iron, molybdenum, uranium, and radium-228 were statistically higher in the southern area compared to VLT samples in the northern area. Copper concentrations in VLT samples were statistically lower in the southern area compared to VLT samples in the northern area. With respect to the sulfide tailings, COI concentrations of total chromium, iron, magnesium, and uranium were statistically higher in the southern area compared to sulfide tailings samples in the northern area. Radium-226 concentrations in sulfide tailings samples were statistically lower in the southern area compared to sulfide tailings samples in the northern area. The results of the statistical testing are shown on Table 4-8.

ProUCL software output data are presented in Appendix 4E. From the statistical testing, a dominant factor controlling the distribution of COIs in OU-4b is material type. Additionally, the use of the southern area of OU-4b for process recycling ponds appears to have influenced COI concentrations in the VLT and sulfide tailings.

As described in Section 2.2.1, Arimetco constructed a landfill in the northern area of OU-4b in the vicinity of STSB-05 and STSB-33. COIs from these locations show similarities to COIs in surrounding locations, suggesting that the landfill is not affecting the distribution of COIs in OU-4b.

Table 4-9 presents a comparison of COI results between the 2019-2020 data, the 2010 Potential Cover Materials Evaluations, and the 2010 Sub-Area A subsurface characterization. Comparisons show that between the three investigations the results are similar. The consistency between the investigations suggests that the observed variability is representative of the nature of the parent rock and of the mine-related material in OU-4b.

4.6.3.2 Individual COI Results

The soil COI geochemical trends are plotted on maps and cross-sections (Figure 4-11 through Figure 4-43) using a consistent color-coding scheme. Concentrations at or below the applicable BCL are shown in green. Concentrations between the BCL and 10 times the BCL are shown in yellow. Concentrations between 10 times the BCL and 100 times the BCL are shown in orange. The intent of the color-coding scheme is to help the reader visualize spatial variations in the COI concentrations. Cross-section locations are shown on Figure 4-1.

Complete COI results as well as the results for other metals and radionuclides not identified as COIs are presented in Appendix 4D. Discussion of the spatial and vertical distribution of each COI is provided below. For comparative purposes and as described in Section 4.6.2, the discussion of each COI is divided into four parts: VLT, sulfide tailings, sulfide tailings-VLT mixture, and native soil material. Native soil material was collected from boreholes that were advanced beyond the bottom of OU-4b at six locations (STSB-01 through STSB-06). In total, 176 samples were collected across 35 field locations (STSB-01 through STSB-35) in OU-4b. Of these samples, 77 were sulfide tailings, 62 were VLT, 24 were a mix of sulfide tailings and VLT, one was of calcines, and 12 were native soil. In terms of locations, all locations

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contained varying amounts of VLT and sulfide tailings, and one location had calcines in addition to VLT and sulfide tailings (as described in Section 4.6.2). Since only one sample out of 176 samples contained calcines, they are not evaluated in the same level of detail as the other materials, however, the results for calcines are summarized in Section 4.6.3.3 and on Table 4-2. As stated in the individual metal summaries below, the mixed samples show characteristics of both material types, such that samples that proportionally contain more VLT than sulfide tailings are more like samples containing only VLT, and vice versa.

Antimony: The distribution of antimony is shown on Figures 4-11 through 4-13 and summarized as follows:

- Antimony concentrations in VLT ranged from 0.38 milligrams per kilogram (mg/kg) to 30 mg/kg. The maximum antimony concentration was detected at location STSB-25 at a depth of 0.5 to 3 feet bgs. Twenty-three of 35 sample locations had at least one VLT sample with a concentration above the antimony BCL of 0.94 mg/kg.

- Antimony concentrations in sulfide tailings ranged from not detected (less than 0.28 mg/kg) to 1.2 mg/kg. The maximum antimony concentration was detected at location STSB-25 at a depth of 6 to 15 feet bgs and was the only sulfide tailings sample with a concentration above the antimony BCL of 0.94 mg/kg.

- Antimony concentrations in the mixed sulfide tailings/VLT samples ranged from not detected (less than 0.29 mg/kg) to 12 mg/kg. The maximum antimony concentration was detected at location STSB-04 at a depth of 0.5 to 3 feet bgs. Four of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the antimony BCL of 0.94 mg/kg.

- Antimony concentrations in native soil ranged from not detected (less than 0.29 mg/kg) to 0.74 mg/kg. The maximum antimony concentration was detected at location STSB-04 at a depth of 69 to 74 feet bgs. No native soil sample concentrations were above the antimony BCL of 0.94 mg/kg.

Antimony concentrations are generally higher in VLT samples compared to sulfide tailings samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT and sulfide tailings sample concentrations are generally similar between the northern and southern areas.

Chromium: The distribution of total chromium is shown on Figures 4-14 through 4-16, and summarized as follows:

- Total chromium concentrations in VLT ranged from 3.5 to 33 mg/kg. The maximum chromium concentration was detected at location STSB-07 at a depth of 0 to 0.5 feet bgs. Four of 35 sample locations had at least one VLT sample with a concentration above the chromium BCL of 11 mg/kg.

- Total chromium concentrations in sulfide tailings ranged from 3.7 to 19 mg/kg. The maximum chromium concentration was detected at location STSB-16 at a depth of 3 to 6 feet bgs. Six of 35 sample locations had at least one sulfide tailing sample with a concentration above the chromium BCL of 11 mg/kg.

- Total chromium concentrations in the mixed sulfide tailings/VLT samples ranged from 4.3 to 14 mg/kg. The maximum chromium concentration was detected at location STSB-12 at a depth of 0.5 to 3 feet bgs. Three of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the chromium BCL of 11 mg/kg.

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- Total chromium concentrations in native soil ranged from 4.6 to 17 mg/kg. The maximum chromium concentration was detected at location STSB-04 at a depth of 69 to 74 feet bgs and was the only sulfide tailings sample with a concentration above the chromium BCL of 11 mg/kg.

Chromium concentrations are generally higher in sulfide tailings samples compared to VLT samples, as shown on Table 4-6. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT and sulfide tailings sample concentrations are generally higher in the southern area.

Copper: The distribution of copper is shown on Figures 4-17 through 4-19, and summarized as follows:

- Copper concentrations in VLT ranged from 390 mg/kg to 2,100 mg/kg. The maximum copper concentration was detected at location STSB-32 at a depth of 0 to 0.5 feet bgs. VLT samples from all 35 sample locations had concentrations above the copper BCL of 58 mg/kg.

- Copper concentrations in sulfide tailings ranged from 130 mg/kg to 2,800 mg/kg. The maximum copper concentration was detected at location STSB-11 at a depth of 6 to 15 feet bgs. Sulfide tailings samples from all 28 sample locations that had sample intervals containing only sulfide tailings had concentrations above the copper BCL of 58 mg/kg.

- Copper concentrations in the mixed sulfide tailings/VLT samples ranged from 150 mg/kg to 2,400 mg/kg. The maximum copper concentration was detected at location STSB-17 at a depth of 3 to 6 feet bgs. All mixed sulfide tailings/VLT samples from the 24 sample locations that had sample intervals containing the mixed samples had concentrations above the copper BCL of 58 mg/kg.

- Copper concentrations in native soil ranged from 10 to 180 mg/kg. The maximum copper concentration was detected at location STSB-05 at a depth of 66 to 71 feet bgs. Four native soil sample concentrations exceeded the copper BCL of 58 mg/kg. Two of these samples were underlain by a native soil sample that did not exceed the BCL. Only one location (STSB-02) did not have a native soil sample at total depth which was below the copper BCL. Concentrations in all remaining native soil samples did not exceed the copper BCL.

Copper concentrations are similar in VLT, sulfide tailings, and mixed sulfide tailings/VLT samples. In general, VLT samples are higher in concentrations in the northern area of OU-4b. Sulfide tailings sample concentrations are generally similar in the northern and southern areas of OU-4b.

Iron: The distribution of iron is shown on Figures 4-20 through 4-22, and summarized as follows:

- Iron concentrations in VLT ranged from 8,700 mg/kg to 41,000 mg/kg. The maximum iron concentration was detected at location STSB-10 at a depth of 0 to 0.5 feet bgs. Ten of 35 sample locations had at least one VLT sample with a concentration above the iron BCL of 19,502 mg/kg.

- Iron concentrations in sulfide tailings ranged from 6,800 mg/kg to 21,000 mg/kg. The maximum iron concentration was detected at two locations, STSB-02 and STSB-03 at depths of 25 to 35 feet bgs at both locations. Three of 35 sample locations had at least one sulfide tailings sample with a concentration above the iron BCL of 19,502 mg/kg.

- Iron concentrations in the mixed sulfide tailings/VLT samples ranged from 9,100 mg/kg to 36,000 mg/kg. The maximum iron concentration was detected at location STSB-18 at a depth of 0.5 to 3 feet bgs. Three of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the iron BCL of 19,502 mg/kg.

- Iron concentrations in native soil materials ranged from 8,400 to 33,000 mg/kg. The maximum iron concentration was detected at location STSB-04 at a depth of 69 to 74 feet bgs. Two native soil sample concentrations exceeded the iron BCL of 19,502. These samples were underlain by

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native soil samples that did not exceed the BCL. Concentrations in all remaining native soil samples did not exceed the iron BCL.

Iron concentrations are similar in VLT, sulfide tailings, and mixed sulfide tailings/VLT samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT and sulfide tailings sample concentrations are generally higher in the southern area of OU-4b.

Magnesium: The distribution of magnesium is shown on Figures 4-23 through 4-25, and summarized as follows:

- Magnesium concentrations in VLT ranged from 3,000 mg/kg to 8,000 mg/kg. The maximum magnesium concentration was detected at location STSB-13 at a depth of 0.5 to 3 feet bgs. Nine of 35 sample locations had at least one VLT sample with a concentration above the magnesium BCL of 6,314 mg/kg.

- Magnesium concentrations in sulfide tailings ranged from 3,500 mg/kg to 9,100 mg/kg. The maximum magnesium concentration was detected at location STSB-03 at a depth of 6 to 15 feet bgs. Nine of 35 sample locations had at least one sulfide tailings sample with a concentration above the magnesium BCL of 6,314 mg/kg.

- Magnesium concentrations in the mixed sulfide tailings/VLT samples ranged from 4,500 mg/kg to 7,800 mg/kg. The maximum magnesium concentration was detected at location STSB-14 at a depth of 0.5 to 3 feet bgs. Seven of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the magnesium BCL of 6,314 mg/kg.

- Magnesium concentrations in native soil materials ranged from 1,400 to 11,000 mg/kg. The maximum magnesium concentration was detected at location STSB-04 at a depth of 69 to 74 feet bgs and was the only sample with a concentration above the magnesium BCL. This sample was underlain by a native soil sample that did not exceed the BCL. Concentrations in all remaining native soil samples did not exceed the magnesium BCL.

Magnesium concentrations are similar in VLT, sulfide tailings, and mixed sulfide tailings/VLT samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT sample concentrations are generally similar between the northern and southern areas. Sulfide tailings sample concentrations are generally higher in the southern area.

Mercury: The distribution of mercury is shown on Figures 4-26 through 4-28, and summarized as follows:

- Mercury concentrations in VLT ranged from 0.035 mg/kg to 6.7 mg/kg. The maximum mercury concentration was detected at location STSB-26 at a depth of 0 to 0.5 feet bgs. VLT samples from all 35 sample locations had concentrations above the mercury BCL of 0.031 mg/kg.

- Mercury concentrations in sulfide tailings ranged from not detected (less than 0.013 mg/kg) to 0.26 mg/kg. The maximum mercury concentration was detected at location STSB-06 at a depth of 25 to 35 feet bgs. Twenty-seven of 35 sample locations had at least one sulfide tailings sample with a concentration above the mercury BCL of 0.031 mg/kg.

- Mercury concentrations in the mixed sulfide tailings/VLT samples ranged from 0.025 mg/kg to 0.90 mg/kg. The maximum mercury concentration was detected at location STSB-04 at a depth of 0.5 to 3 feet bgs. Twenty-two of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the mercury BCL of 0.031 mg/kg.

- Mercury concentrations in native soil ranged from not detected (less than 0.012 mg/kg) to 0.031 mg/kg. The maximum mercury concentration was detected at location STSB-04 at a depth of 69 to 74 feet bgs. This sample is equal to the mercury BCL; however, no other native soil

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sample (including the sample underlaying the 69 to 74 feet bgs sample) had a concentration equal to or above the mercury BCL.

Mercury concentrations are generally higher in VLT samples compared to sulfide tailings samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT and sulfide tailings sample concentrations are generally similar between the northern and southern areas.

Molybdenum: The distribution of molybdenum is shown on Figures 4-29 through 4-31, and summarized as follows:

- Molybdenum concentrations in VLT ranged from 1.6 mg/kg to 20 mg/kg. The maximum molybdenum concentration was detected at location STSB-07 at a depth of 0 to 0.5 feet bgs. VLT samples from all 35 sample locations had concentrations above the molybdenum BCL of 1.7 mg/kg.

- Molybdenum concentrations in sulfide tailings ranged from 1.3 mg/kg to 7.2 mg/kg. The maximum molybdenum concentration was detected at locations STSB-12 at a depth of 3 to 6 feet bgs. Sulfide tailings samples from all 28 sample locations that had sample intervals containing only sulfide tailings had concentrations above the molybdenum BCL of 1.7 mg/kg.

- Molybdenum concentrations in the mixed sulfide tailings/VLT samples ranged from 1.1 mg/kg to 7.3 mg/kg. The maximum molybdenum concentration was detected at location STSB-12 at a depth of 0.5 to 3 feet bgs. Twenty-three of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the molybdenum BCL of 1.7 mg/kg.

- Molybdenum concentrations in native soil ranged from not detected (less than 0.53 mg/kg) to 3.9 mg/kg. The maximum molybdenum concentration was detected at location STSB-02 at a depth of 57.5 to 62.5 feet bgs. Two native soil samples exceeded the molybdenum BCL. One of these samples was underlain by a native soil sample that did not exceed the BCL. Concentrations in all remaining native soil samples did not exceed the molybdenum BCL.

Molybdenum concentrations are generally higher in VLT samples compared to sulfide tailings samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT sample concentrations are generally higher in the southern area of OU-4b. Sulfide tailings sample concentrations are similar between the northern and southern areas of OU-4b.

Selenium: The distribution of selenium is shown on Figures 4-32 through 4-34, and summarized as follows:

- Selenium concentrations in VLT ranged from 1.8 mg/kg to 7.5 mg/kg. The maximum selenium concentration was detected at location STSB-08 at a depth of 0 to 0.5 feet bgs. VLT samples from all 35 sample locations had concentrations above the selenium BCL of 0.8 mg/kg.

- Selenium concentrations in sulfide tailings ranged from 1.1 mg/kg to 3.4 mg/kg. The maximum selenium concentration was detected at location STSB-03 at a depth of 45 to 55 feet bgs. Sulfide tailings samples from all 28 sample locations that had sample intervals containing only sulfide tailings had concentrations above the selenium BCL of 0.8 mg/kg.

- Selenium concentrations in the mixed sulfide tailings/VLT samples ranged from 1.4 mg/kg to 6.0 mg/kg. The maximum selenium concentration was detected at location STSB-17 at a depth of 3 to 6 feet bgs. Mixed sulfide tailings/VLT samples from all 24 sample locations that had sample intervals containing the mixed samples had concentrations above the selenium BCL of 0.8 mg/kg.

- Selenium concentrations in native soil samples ranged from 0.62 mg/kg to 2.6 mg/kg. The maximum selenium concentration was detected at location STSB-04 at a depth of 69 to 74 feet

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bgs. All native soil samples collected from STSB-02 through STSB-05 exceeded the selenium BCL. At STSB-01, no native soil samples exceeded the selenium BCL of 0.8 mg/kg. At STSB-06, the shallower native soil sample (56 to 61 feet bgs) exceeded the BCL, while the deepest sample (66 to 71 feet bgs) did not exceed the BCL.

Selenium concentrations are generally higher in VLT samples compared to sulfide tailings samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT and sulfide tailings sample concentrations are generally similar between the northern and southern areas.

Uranium: The distribution of uranium is shown on Figures 4-35 through 4-37, and summarized as follows:

- Uranium concentrations in VLT ranged from 0.72 mg/kg to 62 mg/kg. The maximum uranium concentration was detected at location STSB-07 at a depth of 0 to 0.5 feet bgs. Sixteen of 35 sample locations had at least one VLT sample with a concentration above the uranium BCL of 2.9 mg/kg.

- Uranium concentrations in sulfide tailings ranged from 0.73 mg/kg to 25 mg/kg. The maximum uranium concentration was detected at locations STSB-12 at a depth of 6 to 15 feet bgs. Sixteen of 35 sample locations had at least one sulfide tailings sample with a concentration above the uranium BCL of 2.9 mg/kg.

- Uranium concentrations in the mixed sulfide tailings/VLT samples ranged from 0.73 mg/kg to 7.0 mg/kg. The maximum uranium concentration was detected at location STSB-07 at a depth of 0.5 to 3 feet bgs. Seven of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the uranium BCL of 2.9 mg/kg.

- Uranium concentrations in native soil material ranged from 0.73 to 4.6 mg/kg. The maximum uranium concentration was detected at location STSB-02 at a depth of 57.5 to 62.5 feet bgs and was the only sample with a concentration above the uranium BCL. This sample was underlain by a native soil sample that did not exceed the BCL.

Uranium concentrations are similar in VLT, sulfide tailings, and mixed sulfide tailings/VLT samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT and sulfide tailings sample concentrations are generally higher in the southern area compared to the northern area in OU-4b.

Radium-226: The distribution of radium-226 is shown on Figures 4-38 through 4-40, and summarized as follows:

- Radium-226 concentrations in VLT ranged from 1.06 picocuries per gram (pCi/g) to 7.44 pCi/g. The maximum radium-226 concentration was detected at location STSB-12 at a depth of 0 to 0.5 feet bgs. Twenty-one of 35 sample locations had at least one VLT sample with a concentration above the radium-226 BCL of 2.04 pCi/g.

- Radium-226 concentrations in sulfide tailings ranged from 0.49 pCi/g to 2.11 pCi/g. The maximum radium-226 concentration was detected at locations STSB-05 at a depth of 15 to 25 feet bgs. Three of 35 sample locations had at least one sulfide tailings sample with a concentration above the radium-226 BCL of 2.04 pCi/g.

- Radium-226 concentrations in the mixed sulfide tailings/VLT samples ranged from 0.939 pCi/g to 5.62 pCi/g. The maximum radium-226 concentration was detected at location STSB-35 at a depth of 6 to 15 feet bgs. Eleven of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the radium-226 BCL of 2.04 pCi/g.

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- Radium-226 concentrations in native soil material ranged from 1.04 pCi/g to 1.88 pCi/g. The maximum radium-226 concentration was detected at location STSB-03 at a depth of 83.5 to 88.5 feet bgs. No native soil sample concentrations were above the radium-226 BCL.

Radium-226 concentrations are generally higher in VLT samples compared to sulfide tailings samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT sample concentrations are generally similar between the northern and southern areas. Sulfide tailings sample concentrations are generally higher in the northern area.

Radium-228: The distribution of radium-228 is shown on Figures 4-41 through 4-43, and summarized as follows:

- Radium-228 concentrations in VLT ranged from 0.534 picocuries per gram (pCi/g) to 7.6 pCi/g. The maximum radium-228 concentration was detected at location STSB-08 at a depth of 0 to 0.5 feet bgs. Two of 35 sample locations had at least one VLT sample with a concentration above the radium-228 BCL of 2.24 pCi/g.

- Radium-228 concentrations in sulfide tailings ranged from 0.622 pCi/g to 2.61 pCi/g. The maximum radium-228 concentration was detected at location STSB-12 at a depth of 3 to 6 feet bgs and was the only sulfide tailings sample with a concentration above the radium-228 BCL of 2.24 pCi/g.

- Radium-228 concentrations in the mixed sulfide tailings/VLT samples ranged from 0.611 pCi/g to 3.42 pCi/g. The maximum radium-228 concentration was detected at location STSB-07 at a depth of 0.5 to 3 feet bgs. Two of 35 sample locations had at least one mixed sulfide tailings/VLT sample with a concentration above the radium-228 BCL of 2.24 pCi/g.

- Radium-228 concentrations in native soil material ranged from 1.1 to 1.86 pCi/g. The maximum radium-228 concentration was detected at location STSB-04 at a depth of 69 to 74 feet bgs. No native soil sample concentrations were above the radium-228 BCL.

Radium-228 concentrations are generally higher in sulfide tailings samples compared to VLT samples. The mixed sulfide tailings/VLT samples show characteristics of both material types. VLT sample concentrations are generally higher in the southern area. Sulfide tailings sample concentrations are generally similar between the northern and southern areas.

4.6.3.3   Calcine Materials

As described in Section 4.6.3.2, Since only one sample out of 176 samples contained calcines, it is not possible to evaluate them in the same level of detail as the other materials. Sample results are summarized on Table 4-2. In general, the sample containing calcines had higher concentrations of chromium and iron when compared to the VLT and sulfide tailings samples. The sample also had concentrations exceeding BCLs for antimony, chromium, copper, iron, mercury, molybdenum, selenium, uranium, and radium-228.

As described in 6.4.2, historical aerial photographs (Appendix 2B) suggest that prior to the sulfide ore processing, calcines, as well as acidic oxide process water from vat leaching operations were discharged over OU-4b. However, the duration of this discharge was limited, and ceased once the sulfide ore processing took place. The extent of discharge over OU-4b was also limited and appears to be generally confined to the southwestern portion of the OU. Transport pathways from the calcines are discussed in Section 4.7.2.

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4.6.4   MWMP and Standing Rain Water Results

MWMP results from the 2019-2020 investigation and the 2013 standing rain water results are discussed in this section.

4.6.4.1 MWMP Results

The MWMP method is generally used for simulating leaching in a surficial or near-surface waste rock environment and has less of a direct application for the subsurface soil environment. As such, there are limitations to evaluating MWMP results; however, the results provide a general estimate of the relative mobility of COIs from OU-4b materials, and will be utilized in the forthcoming SLERA. The estimates could potentially be applicable should the OU-4b material become saturated with surface runoff or groundwater. However, the estimates should be considered conservatively elevated because current conditions make saturation rare or unlikely, such as 1) relatively low precipitation compared to evaporation and 2) the water table is not in contact with the mine-related material in OU-4b.

Summary statistics for MWMP metals and radionuclides COI results are presented in Table 4-3 and MWMP general chemistry results are presented in Table 4-4. As described in Section 4.3.2, MWMP samples were collected from select depth intervals from boreholes in OU-4b. Concentrations of COIs were detected in the MWMP extract with magnesium being detected most often followed by uranium, copper, selenium, molybdenum, iron, radium-226, antimony, total chromium, mercury, and radium-228. MWMP results are presented in Appendix 4D, and a summary of these results for the COIs identified above is provided below.

- **Antimony:** MWMP antimony concentrations ranged from not detected (less than 0.0004 milligrams per liter [mg/L]) to 0.0043 mg/L, with the median of detected values at 0.0013 mg/L. In general, MWMP antimony concentrations were similar in sulfide tailings, VLT, and native soil samples (Table 4-3). MWMP antimony was detected in 40% of MWMP samples, and detection frequencies between sulfide tailings, VLT, and native soil were generally similar.

- **Copper:** MWMP copper concentrations ranged from 0.0009 mg/L to 994 mg/L, with the median of detected values at 82.4 mg/L. In general, MWMP copper concentrations were higher in VLT samples compared to sulfide tailings samples. Both VLT and sulfide tailings sample concentrations were higher compared to native soil samples (Table 4-3). MWMP copper was detected in 95% of MWMP samples, and detection frequencies were similar between sulfide tailings and VLT. Detection frequencies in native soil samples were lower than the other materials.

- **Chromium:** MWMP total chromium concentrations ranged from not detected (less than 0.0005 mg/L) to 0.7 mg/L, with the median of detected values at 0.005 mg/L. In general, MWMP total chromium concentrations in sulfide tailings were higher when compared to VLT and native soil samples (Table 4-3). MWMP total chromium was detected in 38% of MWMP samples, with native soil samples having the most detections, followed by VLT samples, and then sulfide tailings samples.

- **Iron:** MWMP iron concentrations ranged from not detected (less than 0.03 mg/L) to 62.5 mg/L, with the median of detected values at 0.625 mg/L. In general, MWMP iron concentrations were higher in sulfide tailings samples compared to VLT, and native soil samples (Table 4-3). MWMP iron was detected in 55% of MWMP samples, with VLT samples having the most detections, followed by native soil samples, and then sulfide tailings samples.

- **Magnesium:** MWMP magnesium concentrations ranged from 0.4 mg/L to 817 mg/L, with the median of detected values at 101 mg/L. In general, MWMP magnesium concentrations in sulfide

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tailings and VLT samples were both higher compared to native soil samples (Table 4-3). MWMP magnesium was detected in 100% of MWMP samples, regardless of material type.

- **Mercury:** MWMP mercury concentrations ranged from not detected (less than 0.0002 mg/L) to 0.0039 mg/L, with the median of detected values at 0.00035 mg/L. MWMP mercury concentrations were similar in sulfide tailings and VLT samples (Table 4-3). MWMP mercury was detected in only 13% of MWMP samples, with similar detection frequencies in sulfide tailings and VLT samples, and no detections in native soil samples.

- **Molybdenum:** MWMP molybdenum concentrations ranged from not detected (less than 0.0002 mg/L) to 0.333 mg/L, with the median of detected values at 0.0322 mg/L. MWMP molybdenum concentrations were higher in sulfide tailings and native soil samples compared to VLT samples (Table 4-3). MWMP molybdenum was detected in 64% of all MWMP samples. Detection frequencies in sulfide tailings and native soil samples were similar and were higher than VLT samples.

- **Selenium:** MWMP selenium concentrations ranged from 0.0002 mg/L to 0.116 mg/L, with the median of detected values at 0.0201 mg/L. MWMP selenium concentrations were generally higher in sulfide tailings compared to VLT and native soil samples (Table 4-3). MWMP selenium was detected in 88% of MWMP samples, with similar detection frequencies in sulfide tailings, VLT, and native soil samples.

- **Uranium:** MWMP uranium concentrations ranged from 0.0003 mg/L to 4.6 mg/L, with the median of detected values at 0.038 mg/L. MWMP uranium concentrations were generally higher in sulfide tailings and VLT samples compared to native soil samples (Table 4-3). Uranium was detected in 99% of MWMP samples, with similar detection frequencies in sulfide tailings, VLT, and native soil samples.

- **Radium-226:** MWMP radium-226 concentrations ranged from not detected (less than 0.24 picocuries per liter [pCi/L]) to 6.9 pCi/L with the median of detected values at 1.3 pCi/L. Concentrations were generally similar between sulfide tailings, VLT, and native soil samples (Table 4-3). Radium-226 was detected in 51% of MWMP samples; and the detection frequencies were generally the same regardless of material type.

- **Radium-**228: MWMP radium-228 concentrations ranged from not detected (less than 4.1 pCi/L) to 16 pCi/L with the median of detected values at 6.2 pCi/L. Radium-228 was detected in 4% of MWMP samples and was not detected in any VLT or native soil sample (Table 4-3).

- **pH:** MWMP pH values ranged from 3.2 to 8.9 pH units, with a median value of 4.6 pH units. pH values were generally higher in sulfide tailings and native soil samples compared to VLT samples (Table 4-4).

Magnesium, uranium, selenium, and copper were the most often detected COIs in the MWMP samples from OU-4b. These four COIs were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples compared to the solid/total samples (Tables 4-2 and 4-3).

Mercury, chromium, radium-226, and radium-228 were detected in approximately 13%, 38%, 51%, and 4%, respectively, of the MWMP samples. For comparison, these COIs were detected in 92%, 100%, 100%, and 100%, respectively, of the solid/total samples (Tables 4-2 and 4-3). The lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in OU-4b mercury, chromium, radium-226, and radium-228 are likely to be less mobile than the other COIs.

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Antimony, iron, and molybdenum were detected in approximately 40%, 55%, and 64%, respectively, of the MWMP samples. For comparison, these COIs were detected in 59%, 100%, and 98%, respectively, of the solid/total samples (Tables 4-2 and 4-3). The lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in OU-4b antimony, iron, and molybdenum are likely to be less mobile than the other (above) COIs. Unlike other COIs, the detection frequencies for these COIs varied among the different material types. In MWMP samples from sulfide tailings, iron was detected less frequently compared to VLT and native soil samples. In MWMP samples from VLT, antimony and molybdenum were detected less frequently compared to sulfide tailings and native soil samples.

With respect to material types, in general there are inconsistent trends in terms of MWMP COI concentrations, such that for some COIs concentrations were similar across the three material types, whereas for other COIs concentrations were either higher or lower depending on the material type. In a similar manner, inconsistent trends were also seen in the detection frequencies and potential relative mobilities. This suggests that material type may affect the leaching potential differently for different COIs, and that there is uncertainty in assigning relative mobility to COIs. Also, in the context of the MWMP results, COI mobility refers to the dissolved fraction.

As discussed above, MWMP results are a conservative estimate of the leaching potential of the sample material and potential effects on water quality should the material become saturated with surface runoff or groundwater, though current conditions make such saturation rare or unlikely.

4.6.4.2 Standing Rain Water Results

Surface water is not typically present within OU-4b. As discussed in Section 4.1.3, one surface water sampling event was conducted during a period when standing water was ephemerally present. From this event, one standing rain water sample, SRW-SAA-1, was collected from OU-4b.

The standing rain water sample was collected on July 10, 2013, six days after the rain event. The total dissolved solids concentration from the sample was 17,000 mg/L, and the measured pH value was 2.71. A possible mechanism for the observed TDS and pH values is the rapid dissolution of soluble efflorescent metal salts. However, while such dissolution is possible, metal salts have not been observed on the surface of OU-4b. As described further below, given the limited availability of standing rain water for sampling, it is not possible to draw definitive conclusions on mechanisms affecting the chemistry of the water sample. COI concentrations from the one sample consisted of:

- Antimony – not detected (less than 0.003 mg/L)
- Copper – 220 mg/L
- Iron – 27 mg/L
- Magnesium – 760 mg/L
- Mercury – not detected (less than 0.0001 mg/L)
- Molybdenum – 0.08 mg/L
- Selenium – 0.044 mg/L
- Uranium – 13 mg/L
- Radium-226 – 20.8 pCi/L

Because of the ephemeral nature of standing rain water, the rarity of large rain events that would produce standing rain water, and the limited number of samples, standing rain water is not considered a significant

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media in describing the nature and extent of COIs in OU-4b. However, the data may be utilized in the forthcoming HHRA or SLERA.

4.6.5   Acid Base Account Results

ABA analysis is a method to assist in predicting and assessing the acid generation and neutralization potential of waste rock. As described in Section 4.3.2, ABA samples were collected from select sample intervals at all borehole locations. ABA summary statistics are presented in Table 4-5. ABA consists of multiple analyses, including acid generating potential (AGP), acid neutralization potential (ANP), the neutralization potential ratio (NPR), and the net neutralization potential (NNP).

AGP is a measure of the total amount of acid a material can generate and is reported in units of tons of calcium carbonate per kiloton. ANP is a measure of the total amount of acid a material is capable of neutralizing. The NPR and NNP are calculated from the ANP and AGP. The NPR is calculated by dividing ANP by AGP (NPR = ANP/AGP). The NNP is calculated by subtracting AGP from ANP (NNP = ANP – AGP).

Both NPR and NNP parameters are ways to assess the relative amounts of ANP and AGP and are used in prediction of the likelihood of sulfidic material to become acid generating. The assumption is that all the acid generation and neutralization occur in the tested material and there is not an external source of acidity moving into the soil from surroundings. General criteria for predicting whether material is potentially acid-generating (PAG) or non-potentially acid-generating (non-PAG) material are shown below:

NPR:

- NPR < 1 = PAG

- NPR > 3 = Non-PAG in Nevada

- 1 ≤ NPR ≤ 3 = Uncertain

NNP:

- NNP < -20 = PAG

- NNP > 20 = Non-PAG

- -20 ≤ NNP ≤ 20 = Uncertain

Figure 4-44 shows charts of NPR by material type in OU-4b. The sulfide tailings and the sulfide tailings-VLT mix had the highest number of PAG samples at 33% and 55% respectively. Native soil samples had the highest number of non-PAG samples at 83%. The majority of VLT samples fell in the uncertain range, with smaller percentages of PAG or non-PAG samples (12% and 6%, respectively). With respect to the sulfide tailings-VLT mix samples, those mixed samples composed of a majority of VLT material are more similar to samples that are composed entirely of VLT material. Additionally, the mixed samples composed of a majority of sulfide tailings are more similar to samples that are composed entirely of sulfide tailings.

Figure 4-45 shows charts of NNP by material type in OU-4b. For the VLT, sulfide tailings, and sulfide tailings-VLT mixed samples, the majority of NNP values fell in the uncertain range and less than 5% were in either the PAG or non-PAG category. For the native soil samples, all NNP values were either in the uncertain or non-PAG category.

The NAG test can be used to potentially resolve uncertainties from the ABA analysis (Stewart, et al., 2006). For NNP values less than zero but still in the uncertain range of classification, if the NAG pH is less than 4.5 and the NAG is greater than 5 kilograms sulfuric acid per ton, then the material is more likely to be PAG. Conversely, for NNP values greater than zero but still in the uncertain range, if the NAG pH is greater

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than 4.5, the material is more likely to be non-PAG (AMIRA, 2002). Figure 4-45 presents the results of this classification along with the NNP results. Using the NAG as a supplement to the NNP suggests that the majority of all samples from all material types are likely non-PAG. In addition, the results are consistent with the classification from the NPR and NNP that suggest that, of the samples that can be classified as PAG, the sulfide tailings have the highest number of samples.

When looking at the NPR and NNP, using the NNP alone for PAG classification yields more uncertain results, making PAG classification using NPR or the NNP with NAG a more conservative approach. Materials classified as PAG have the potential to generate acidic pH values; however, it does not assure that acidic conditions will be realized. As described further in Section 4.7, the materials in OU-4b have very limited contact with significant amounts of surface runoff or groundwater, which would limit the amount of or preclude acid generation from the sulfide tailings and VLT.

In general, the sulfide tailings have a greater percentage of samples that can be classified as PAG, compared to VLT samples. From the laboratory analysis, sulfide tailings samples also have higher overall values of AGP. Pyritic sulfur, potentially acid generating sulfur, water soluble sulfate, and total sulfur were also generally detected similarly or more often and at overall higher concentrations in sulfide tailings samples compared to VLT (Table 4-5). These differences in concentrations support that the sulfide tailings have a greater percentage of samples that can be classified as PAG. Paste pH values are generally lower in VLT samples when compared to sulfide tailings; however, based on the other analysis, VLT is less likely to be acid generating when compared to the sulfide tailings.

4.7 Fate and Transport

This section primarily discusses the fate and transport of COIs OU-4b. Potential routes of migration are described in the following sections.

4.7.1 Geochemical Characteristics

COIs within OU-4b are inorganic chemicals. Except for radionuclide COIs, these inorganic chemicals do not transform or degrade into other chemicals that exhibit different toxicity or mobility.

4.7.2 Potential Transport Pathways and Mechanisms

As described in Section 4.2.2, the potential transport mechanisms evaluated for OU-4b consist of:

- Transport by water erosion/surface water runoff
- Leaching/percolation to subsurface soil
- Transport to groundwater
- Transport by wind erosion

Each of these potential transport pathways are discussed below.

4.7.2.1 Transport by Water Erosion/Surface Water Runoff

The low annual precipitation for ACMS results in few events capable of eroding and transporting COIs in OU-4b. Other than the Phase 2 tailings embankment which surrounds the OU, OU-4b does not have significant topographic relief. The Arimetco borrow pit (Figure 2-1) has the potential to collect surface water runoff; however, this feature is internally draining such that any runoff would not be transported away from the OU. Any potential transport that does occur would likely be from the top of the tailings embankment to the base of the embankment. The embankment is largely composed of VLT, based on historical documentation (CH2M Hill, 2010) and field observations (Appendix 4F contains a photolog

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documenting current conditions of the perimeter of OU-4b). VLT generally contains a low percentage of fines, as observed during sampling (Section 4.3.2.1 and Appendix 4B). Because the embankment is composed of coarser-grained material, transport of COIs away from OU-4b in surface water runoff is not expected to occur. Transport from OU-4b is also constrained by the topographically higher Ground Hog Hills (southeast), and the OU-3 process area (southwest).

Field observations did not detect mobilization of material away from the OU-4b via runoff (Appendix 4F). Some rilling (formation of shallow channels cut into the surface by runoff) was observed on the sides of the embankment on the eastern and northern boundaries of OU-4b, along with slumping of the embankment in the northeastern corner of the embankment. However, any associated effects appear to be limited to the areas at the base of the embankment. The Wabuska Drain, north of OU-4b (Section 2.2.1), is the closest potential receiving surface water body. However, as described in the *Final Wabuska Drain Operable Unit 7 Remedial Investigation Report* (Wood, 2020e), there is no observed surface water flow from ACMS to the Wabuska Drain, which currently collects agricultural runoff from fields located north of OU-4b. There are several impediments that would prevent surface flow from the ACMS from reaching the Wabuska Drain, including a soil berm along the southern and western edge of the Drain and depressions in the flat area to collect surface water runoff and sediment between the Drain and OU-4b (Wood, 2020e).

As a result of the factors listed above, the water erosion/surface water runoff transport pathway away from OU-4b is incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives.

4.7.2.2 Leaching/Percolation to Subsurface Soil

The low annual precipitation and high annual evaporation rates currently make transport of COIs from the sulfide tailings to the underlying soil unlikely. The thicknesses of the mine-related material in OU-4b is variable, ranging from 28 to 68.5 feet. During the OU-4a RI (CEC, 2019), an evaluation of the vadose zone details shows that because of an annual pan evaporation rate that is approximately 13 times higher than the annual precipitation rate, a strong net evaporative condition exists in the vadose zone. Additionally, the OU-4a RI suggests that the wetting front from even large winter precipitation events (e.g., January 2017) likely has limited impact in the subsurface. VLT at the surface of OU-4b may be generally coarser than the OU-4a soils; however, the sulfide tailings are likely similar or finer grained than the OU-4a soils. As such, the infiltration and evaporation processes in OU-4b are expected to be similar to the limited infiltration and highly evaporative processes measured in OU-4a.

Because of the thickness of the mine-related materials and given the annual climatic conditions, no discernible downward percolation of precipitation or impacts to subsurface soils are expected in OU-4b. The impact of larger storm events would likely be similarly limited, given the high evapotranspiration conditions at ACMS. No mechanism currently exists for sufficient amounts of precipitation to reach the subsurface or to cause elevated metals concentrations or acidic soil conditions.

A comparison of metals concentrations in mine-related material and the underlying native soil indicates that six of the nine COIs (copper, iron, magnesium, molybdenum, selenium, and uranium) are present at concentrations above their respective BCLs in native soil samples collected beneath OU-4b. Iron, magnesium, and uranium exceedances in native soil samples were all underlain by samples below their respective BCLs. Copper and molybdenum exceedances in the deepest native soil sample were limited to one location each. Selenium concentrations above the BCL are also present in native soil; however, concentrations are less than twice the BCL.

With respect to concentrations above BCLs in native soil, and as discussed in Section 4.6.1, the presence of a pre-mining playa-like deposit in the area of OU-4b may have resulted in enrichment of COIs in native

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soil. In addition, erosion and deposition from the Ground Hog Hills and underlying Bear Deposit, located southeast of OU-4b, may have been a source of mineralization to pre-mining native soils beneath OU-4b. Because no discernible downward percolation of precipitation is expected, the source of the concentrations above BCLs in native soil beneath OU-4b are likely a result of these pre-mining conditions. In addition, past mining and mineral processing activities may have affected subsurface soil beneath OU-4b. Historical aerial photographs (Appendix 2B) suggest that prior to the sulfide ore processing, acidic oxide process water from vat leaching operations as well as calcines were discharged over OU-4b. However, the duration of this discharge was limited, and ceased once the sulfide ore processing took place. The extent of discharge over OU-4b was also limited and appears to be generally confined to the southwestern portion of the OU. Any impacts from the acidic oxide process water would have been neutralized once discharge of the alkaline sulfide tailings began. Furthermore, accumulation of the sulfide tailings in OU-4b has prevented exposure and potential impacts in the underlying soil.

As a result of the factors listed above, the leaching/percolation transport pathway to subsurface soil beneath OU-4b is currently incomplete for the purposes of performing the risk characterization and evaluating remedial alternatives.

4.7.2.3   Transport to Groundwater

Consistent with the previously described media, the RI did not identify evidence of or a mechanism for discernible mobilization of COIs to groundwater beneath OU-4b. As described in the OU-1 FRIR, OU-4b was not considered a major source of COIs in groundwater, and migration of groundwater from beneath the sulfide tailings was also not considered significant (CEC, 2020). The OU-1 FRIR (CEC, 2020) states that concentrations of COIs in groundwater beneath OU-4b are generally at least 10 times lower than COI concentrations in groundwater beneath OU-4a. Prior to agricultural activities, groundwater flow from OU-4b was to the north. However, agricultural activities over the last half century have shifted groundwater flow under OU-4b toward the west and southwest. As a result, OU-4b is located hydraulically upgradient or cross-gradient of OU-4a in the Shallow and Intermediate Zones, and part of the groundwater beneath OU-4b flows toward the higher COI concentrations under OU-4a (CEC, 2020).

Despite these current conditions, the OU-1 FRIR (CEC, 2020) indicates that mine influenced water (MIW) is present beneath OU-4b. As described in Section 4.7.2.2, past mining and mineral processing mining activities may have affected groundwater beneath OU-4b. However, these effects were limited in time and extent, and are not indicative of current conditions.

In addition, the vadose zone in the native soil beneath the sulfide tailings ranges from approximately 15 to 70 feet thick. COIs beneath the OU-4b would need to migrate through this vadose zone. As described in the Section 4.7.2.2, evaporation exceeds average annual precipitation, and the wetting front from even large winter precipitation events likely has limited impact in the subsurface. The OU-4a RI presented a discussion on the occurrence of large precipitation events (approximately 2.34 inches at ACMS) including a 10-day storm event in January 2017 (CEC, 2019). The report noted that such events are rare and that from the period of 1960 to 2016, only two larger events have been measured in the area of ACMS (CEC, 2019). This suggests that larger precipitation events are infrequent and that any impact beneath OU-4b due to a large precipitation event would also be infrequent and discontinuous, such that flux of COIs to the water table under current conditions, is not discernable. Future flux of COIs through the vadose zone is not expected except perhaps under extreme conditions that result in extensive ponding, infiltration, and prolonged deep soil saturation.

Based on these factors, the transport pathway to groundwater beneath OU-4b is likely incomplete and will be so in the future. As such, the pathway will be incomplete for the purposes of performing the risk assessments and evaluating remedial alternatives. This is further confirmed by relatively low and/or stable

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Shallow Zone groundwater COI concentrations and circumneutral pH values in the vicinity of the OU-4b at wells B/W-29S, B/W-36S, B/W-37S, B/W-38RS, and UW-1S (Wood, 2020d). Further evaluation of groundwater transport beneath ACMS is included in the OU-1 FRIR (CEC, 2020). The Optimized Groundwater Monitoring Program (Wood, 2020) will continue to track potential future COI migration downgradient and cross gradient from OU-4b.

4.7.2.4 Transport by Wind Erosion

Wind-blown dust was monitored along the ACMS perimeter from January 2005 through March 2008 (BC, 2005; BC, 2009c). Results from the monitoring program indicated that no additional air quality data were needed to perform a risk assessment on the inhalation pathway. This risk assessment was performed as described in the *Baseline Human Health Risk Assessment for the Inhalation Pathway* (BC and Foxfire Scientific, 2011). The risk assessment concluded that there is no unacceptable heath risk attributable to a dust inhalation pathway. In addition, fugitive dust prevention has been addressed in areas of ACMS, including the placement of VLT cover on the sulfide tailings and Thumb Pond, and the application of a binding agent onto the lined and unlined evaporation ponds (ARC, 2010; BC, 2011a). Because air transport from Site facilities has been addressed on a Site-wide basis, it is not evaluated further in this report.

4.7.3 Updated Conceptual Site Model

Based on the information presented in Section 4.7.2, the preliminary CSM presented in Section 4.2 has been updated to include a summary of the routes of transport and the physical nature of OU-4b. The CSM is presented schematically in Figure 4-46. This CSM does not include exposure pathways or receptors as those will be developed in the forthcoming risk assessment as described in Section 7.0.

Consistent with Section 4.2, the CSM describes post-process solid materials from sulfide ore beneficiation that were emplaced within the Phase 1 and 2 tailings embankments described in Section 2.2.1. The majority of OU-4b is composed of sulfide tailings, along with VLT cover materials. Sulfide tailings were generated during the fine crushing of the sulfide ore during the beneficiation process. After the removal of the copper through a floatation process, the fine-grained (fine sand, silt, and clay sized) tailings were deposited as a slurry in designated areas within the tailings embankments. Following deposition, the tailings were covered with VLT. Because the sulfide tailings and VLT cover materials were generated under extensive, controlled beneficiation processes, these materials generally display a consistent range of concentrations across OU-4b. Subsequent post-emplacement construction of the process evaporation and recycling pond in the southern portion of OU-4b resulted in some spatial variability in COIs between the northern and southern areas of the OU, as described further below.

Based on the recent investigation, the thickness of the mine-related material (VLT, sulfide tailings, and calcines) ranged from approximately 24.5 feet to 68.5 feet. Of the mine-related material, the VLT ranged in thickness from approximately 0.5 to 14.5 feet, and the sulfide tailings ranged in thickness from approximately 19.25 to 65.5 feet. The native soil contact beneath the sulfide tailings generally slopes from the south and southeast to the north and northwest. Generally, VLT thicknesses increase in the northern portion of OU-4b. The vadose zone extends approximately 15 feet beneath the sulfide tailings in the northern portion of OU-4b to approximately 70 feet beneath the sulfide tailings in the southern portion of OU-4b.

The range of concentrations and textures observed in the sulfide tailings are due to natural variability in the composition of the ore, as well as emplacement and post-emplacement processes. Minor variations in texture occurs across the OU, with finer grained sulfide tailings present close to the tailings embankments and farther from historical discharge points. Conversely, less fines are present closer to historical discharge points. However, the finer grained sulfide tailings seen behind the tailings embankments make

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up less than 5% of the sulfide tailings seen in OU-4b. As such, much of the OU displays a more consistent texture. During mining operations, there were likely variable and migrating discharge locations which resulted in overall lower variability in textures in the tailings impoundments. The presence of process water in the process evaporation or recycling ponds constructed south of the Phase 1 tailings embankments (Section 2.2.1) likely resulted in differing COI concentrations in the VLT and sulfide tailings when comparing the northern and southern areas.

The presence of a pre-mining playa-like deposit in OU-4b may have resulted in enrichment of COIs in native soil. In addition, erosion and deposition from the Ground Hog Hills, located southeast of OU-4b, may have been a source of mineralization to pre-mining native soils beneath OU-4b. Because no discernible downward percolation of precipitation is expected, the source of the concentrations above BCLs in native soil beneath OU-4b are likely a result of these pre-mining conditions. In addition, past mining and mineral process activities may have affected subsurface soil and may have resulted in MIW that is present beneath OU-4b. Prior to the sulfide ore processing, acidic oxide process water from vat leaching operations as well as calcines were discharged over OU-4b. However, the duration of this discharge was limited, and ceased once the sulfide ore processing took place. The extent of discharge over OU-4b was also limited and appears to be generally confined to the southwestern portion of the OU. In addition, any effects from the acidic oxide process water would have been neutralized once discharge of the alkaline sulfide tailings began.

Vertical transport of COIs from OU-4b to the sub-surface is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the sulfide tailings.

4.8   Results Summary

Results for OU-4b are as follows:

- In 2019-2020, samples were collected from 29 shallow and six deep boreholes. The shallow boreholes were advanced to 15 feet bgs. The deep boreholes were advanced to native soil and then an additional 20 feet. In the six deep boreholes (STSB-01 through STSB-06) the thickness of the OU-4b materials were observed to be 48, 73, 89, 84, 81, and 71 feet bgs, respectively.

- Samples were submitted for laboratory analysis of metals and radionuclides at all locations and sample depth intervals. At select locations and depth intervals, samples were also submitted for laboratory analysis of MWMP extract and ABA/NAG.

- COIs were identified by evaluating the data against BCLs. Based on the comparison, antimony, total chromium, copper, iron, magnesium, mercury, molybdenum, selenium, uranium, radium-226, and radium-228 were retained as COIs and evaluated in this RI.

- Several mine-related material types were observed during sampling. VLT was present at the surface of all locations and overlies sulfide tailings. For five of the six locations advanced to native soil, the sulfide tailings overlaid native soil. However, at location STSB-02, the sulfide tailings overlaid calcines, which in turn overlaid native soil.

- A subset of the samples contained a mixture of sulfide tailings and VLT. From this classification, approximately 50% of the mine-related material samples are classified as sulfide tailings, 35% as VLT, and 15% as mixed sulfide tailings/VLT.

- OU-4b soil contains COI concentrations above their respective BCL. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, antimony, magnesium, iron, total chromium, and radium-228.

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- Some spatial geochemical variability is observed laterally and vertically in OU-4b. Two-sample hypothesis testing was performed to assess COI differences between the different material types and geographic position. The variability seen in OU-4b samples appears to be controlled largely by material type, and by the tailings area (Phase 1 or Phase 2) in which the sample is located.

- Two-sample hypothesis testing was also performed to assess COI differences between the different depth intervals in the upper 15 feet at locations STSB-01 though STSB-35. Based on the testing, the trends by depth were less clear than those by material type, suggesting that while there are statistical differences by depth in the upper 15 feet, these overlap with differences by material type.

- Concentrations of COIs were detected in the MWMP extract with magnesium being detected most often followed by uranium, copper, selenium, molybdenum, iron, radium-226, antimony, total chromium, mercury, and radium-228. Magnesium, uranium, selenium, and copper were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples compared to the solid/total samples.

- When looking at the NPR and NNP, using the NNP for PAG classification yields more uncertain results, making PAG classification using NPR or the NNP with NAG a more conservative approach. Using the NPR, the sulfide tailings and the sulfide tailings-VLT mix had the highest number of PAG samples at 33% and 55%, respectively. Native soil samples had the highest number of non-PAG samples at 83%. The majority of VLT samples fell in the uncertain range, with smaller percentages of PAG or non-PAG samples (12% and 6%, respectively).

- In general, the sulfide tailings have a greater percentage of samples that can be classified as PAG, compared to VLT samples. Sulfide tailings samples also have higher overall values of AGP. Pyritic sulfur, potentially acid generating sulfur, water soluble sulfate, and total sulfur were generally detected more often and at overall higher concentrations in sulfide tailings samples with respect to VLT. These differences in concentrations support the conclusion that the sulfide tailings have a greater percentage of samples that can be classified as PAG. Paste pH values are generally lower in VLT samples when compared to sulfide tailings; however, based on the other analysis, VLT is less likely to be acid generating when compared to the sulfide tailings.

- The CSM describes post-process solid materials from sulfide ore beneficiation that were emplaced within the Phase 1 and 2 tailings embankments described in Section 2.2.1. The majority of OU-4b is composed of sulfide tailings, along with VLT cover materials. Sulfide containing tailings were generated during the fine crushing of the sulfide ore during the beneficiation process. After the removal of the copper sulfides through a floatation process, the fine-grained (fine sand, silt, and clay sized) tailings were deposited as a slurry in designated areas within the tailings embankments. Following deposition, the tailings were covered with VLT to control dust. Because the sulfide tailings and VLT cover materials were generated under extensive, controlled beneficiation processes, these materials generally display a consistent composition across OU-4b. Subsequent post-emplacement construction of the process evaporation and recycling pond in the southern portion of OU-4b resulted in some spatial variability in COIs between the northern and southern areas of the OU.

- Currently, as described in Section 4.7, transport of COIs away from OU-4b is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the sulfide tailings.

- As described in the OU-1 FRIR (CEC, 2020), OU-4b was not considered a major source of COIs in groundwater. The OU-1 FRIR states that concentrations of COIs in groundwater beneath OU-4b

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are generally at least 10 times lower than COI concentrations in groundwater beneath OU-4a. Prior to agricultural activities, groundwater flow from OU-4b was to the north. However, agricultural activities over the last half century have shifted groundwater flow under OU-4b to the west and southwest. As a result, OU-4b is located hydraulically upgradient or cross-gradient of OU-4a in the Shallow and Intermediate Zones, and part of the groundwater beneath OU-4b flows toward the higher COI concentrations under OU-4a (CEC, 2020).

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5.0 OU-5 – Waste Rock Areas

The RI information for OU-5 is presented in this section. A summary and conclusion of the results is presented in Section 5.8, and in discussion with the other OUs in Section 8.0.

5.1 Summary of Previous Investigations and Assessments

Investigations and assessments conducted within and regarding OU-5 are described in the following sections. In general, the previous investigations presented in Sections 5.1.1 (1992 Waste Rock Characterization of W-3) and 5.1.2 (2001 Emergency Response Assessment) are discussed for reference purposes only. The investigation in Section 5.1.3 (2010 Characterization of Potential Cover Materials) is presented for use in comparisons to more recent data. Section 5.1.4 summarizes the 2018 Peripheral Area Investigation (PAI) for W-3 and S-23 that has already been presented in the OU-8 PA RI/FS (Wood, 2020a). Section 5.1.5 summarizes a 2018 Pre-Design Component Investigation (PDCI) which will be included in the data evaluation presented later in this document. Finally, Section 5.1.6 summarizes a 2020 material screening assessment of the South WRA. As described further in Section 5.5, all of the data from the previous investigations described in Sections 5.1.3 through Section 5.1.5 are of sufficient quality for use in the RI and forthcoming HHRA and SLERA.

The South WRA has been selected as a preferred source of alluvial cover material for use during the Record of Decision (ROD) 1 (OU-8) implementation. Additional geotechnical details and information are presented in the *ROD 1 Arimetco Facilities (OU 8) Remedy, Regrade/Cap of Heap Leach Pads and Select Peripheral Areas, Design Summary* (Wood, 2020c).

5.1.1 1992 Waste Rock Characterization of W-3

Arimetco collected samples from waste rock area W-3 for laboratory analysis. MPEL Laboratory conducted an MWMP analysis with water artificially modified to a pH of 6.12 to simulate natural meteoric (rain) water. A static test was also conducted on the same sample to identify acid-generating potential. The report provides analytical results, but no discussion or evaluation of the results is included. Limited information exists for this investigation, and it does not meet the documentation requirements for the RI. As such, it is discussed here for historical context only and data from the investigation are not evaluated in the RI. It is unknown if the investigation was conducted under a QAPP.

5.1.2 2001 Emergency Response Assessment

The U.S. EPA Superfund Technical Assessment and Response Team collected waste rock samples from S-23 and W-3 as part of an initial CERCLA evaluation of the Site (START, 2001). Samples were analyzed for metals. Limited information exists for this investigation, and it does not meet the documentation requirements for the RI. As such, it is discussed here for historical context only and data from the investigation are not evaluated in the RI. It is unknown if the investigation was conducted under a QAPP.

5.1.3 2010 Characterization of Potential Cover Materials

ARC performed an investigation that collected data to: 1) support decisions regarding materials that may be used for interim covers and/or the design of final closure caps; and 2) supplement pre-existing data (ARC, 2011). Samples were collected from multiple areas of the ACMS: native alluvium, South WRA, W-3, S-23, oxide tailings, sulfide tailings, and HLP materials. The investigation was conducted under QAPP Version 5.0.

In OU-5 samples were collected from the South WRA, W-3, and S-23 areas as follows:

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- In the South WRA, five locations (CM-SWR-01 through -05; Figure 5-1) were sampled using a backhoe. The material sampled consisted of four alluvial soil stockpiles and one waste rock stockpile. In addition, four surface rock grab samples of waste rock were collected (CM-SWR-06 through 09). The surface rock grab samples targeted, in part, rocks that displayed a high degree of mineralization.

- In W-3 and S-23, three locations in each area (CM-WR3-01 through CM-WR3-03 and CM-S23-01 through CM-S23-03; Figure 5-1) were sampled by backhoe and four locations in each area (CM-WR3-04 through CM-WR3-07 and CM-S23-04 through CM-S23-07; Figure 5-1) were sampled for surface rock grab samples.

All samples were submitted for laboratory analysis of plant growth parameters, metals and radionuclides, MWMP metals and radionuclides, ABA/NAG, and geotechnical properties. The MWMP leachate analysis included the NDEP BMRR Profile II list of analytes in addition to radionuclides and general chemistry parameters (bicarbonate alkalinity, and total alkalinity).

Results from the waste rock areas were evaluated for potential use as cover material relative to six categories:

- metals and radionuclides mean/maximum values,

- MWMP leachate concentrations less than drinking water MCLs,

- acid-generating potential,

- potential to support plant growth,

- plant-available moisture storage capacity,

- and saturated hydraulic conductivity.

Relative to the other materials evaluated, the soil samples from the South WRA were most favorable for use as cover material for all categories except for MWMP leachate concentrations, which was moderately favorable. Samples from W-3, S-23, and all the surface rock grab samples were either moderately favorable or least favorable for all categories. The investigation did not provide recommendations on which materials are suitable as a cover material. Data from this investigation is presented in Appendix 5A.

5.1.4   2018 Peripheral Area Investigation

The OU-5 W-3 and S-23 waste rock areas were sampled in 2018 as part of the PAI (Wood, 2020a). Shallow soil sampling was conducted by hand and using an excavator to maximum depth of six feet. Deep soil sampling was conducted using a sonic drill rig. The investigation was conducted under QAPP Version 5.1.

Shallow soil samples were collected from eight locations across W-3: WRSB-001, WRSB-002, WRSB-003, WRSB-004, WRSB-006, WRSB-007, WRSB-009, and WRSB-010, as shown on Figure 5-1. Shallow soil sampling was not conducted on S-23. Boreholes were advanced at two locations on W-3 (WRSB-005 and WRSB-008, Figure 5-1) and at three locations on S 23, (WRSB-101 through WRSB-103, Figure 5-1). Boreholes WRSB-005, WRSB-008 and WRSB-102 were advanced into native soil material beneath the piles. During drilling, native soil was encountered at depths of 197 feet bgs, 144 feet bgs, and 99 feet bgs, respectively.

Samples collected during the investigation were analyzed for metals, radionuclides, ABA/NAG, MWMP metals and general chemistry parameters, and agronomic parameters (agronomic parameters were collected for future potential use in the FS and are not evaluated in this document). The RI for W-3 and S-23 has already been completed, as presented in the OU-8 PA RI/FS (Wood, 2020a). General conclusions

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from the OU-8 PA RI/FS relating to W-3 and S-23 are included in Section 5.8 and Section 8.0 of this RI Report. Data from W-3 and S-23 are presented in Appendix 5A.

5.1.5   2018 Pre-Design Component Investigation

The *Remedial Design/Remedial Action Work Plan for ROD 1 Closure Management Units* (RD/RA Work Plan) (Wood, 2018), included a PDCI which described data collection activities to support RD/RA activities. In conjunction with the PDCI and in discussion with the NDEP, an additional scope of work for the VLT across OU-6 and the South WRA in OU-5 was developed. The objective of sampling the VLT and South WRA was to collect soil geochemical and agronomic data in support of the RD/RA cover materials evaluation. For the VLT, additional geochemical data was needed throughout OU-6. In the South WRA, additional geochemical and agronomic data was needed in the northwest portion of the waste rock where, in general, more alluvium is located.

The scope of the investigation in the South WRA consisted of advancing five boreholes (WRSB-201 through WRSB-205, Figure 5-1) to depths ranging from approximately 27 to 110 feet bgs and collecting composite samples for laboratory analysis from each borehole. Borehole depths varied and were based on the anticipated thickness of the waste rock at each location. Samples collected during the investigation were analyzed for metals, radionuclides, ABA/NAG, MWMP metals and general chemistry parameters, and agronomic parameters.

The results of this scope of work were originally presented in the *2018 Vat Leach Tailings and South Waste Rock Technical Memorandum* (VLT and South WRA memo) (Wood, 2020b), which was included as Appendix C to the *Remedial Design Materials Screening Assessment* (MSA) (Ramboll and Arcadis, 2020). This in turn was included as Appendix J to the *ROD 1 Arimetco Facilities (OU 8) Remedy, Regrade/Cap of Heap Leach Pads and Select Peripheral Areas, Design Summary* (Wood, 2020c). For reference, the MSA including the VLT and South WRA memo are presented again in this document in Appendix 5B. The MSA is described in further detail in the next section.

5.1.6   2020 Material Screening Assessment

As described above, the MSA was prepared as an appendix to support RD/RA work in OU-8. The purpose of the assessment was to document screening results intended to support selection of cover materials that may be placed on the HLPs and other areas to achieve post-closure performance standards (Ramboll and Arcadis, 2020). The MSA evaluated available South WRA data and prepared risk evaluations for the South WRA and VLT, which included both human health and ecological risk-based screening components.

For the South WRA, the MSA concluded that from a human health perspective, the use of South WRA material as a cover material is considered acceptable under current/future industrial land uses within the former mine property. From an ecological perspective, exposure to South WRA material is not expected to pose an elevated risk of adverse effects (Ramboll and Arcadis, 2020).

5.2   Preliminary Conceptual Site Model

Information relating to a CSM for OU-5 has been presented previously in two documents. The relevant information from the physical CSM (Wood, 2019) and Site-wide CSM (BC, 2009a) is summarized in the following sections.

5.2.1   Physical Setting

As described in Section 2.2.2, OU-5 comprises three waste rock areas (Figure 1-2). The CSM for W-3 and S-23 has previously been presented in the OU-8 PA RI/FS, and relevant information from the CSM is summarized below in Section 5.8 and again in Section 8. The physical CSM presented in the Combined

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FSAP was limited to the South WRA as that was the focus of the sampling for OU-5 described in the Combined FSAP.

The South WRA is comprised of approximately 90 million tons of alluvial material removed above the ore body and approximately 25 million tons of rock waste generated from removal of the cap rock above the ore (CH2M Hill, 2010). The variability of the source materials may result in physical and chemical variability in the waste piles. The materials comprising the South WRA are a potential source of metals and/or radionuclides, but the source materials are assumed to be non-mineralized and have not been processed unlike the mine-related material in OU-4b and OU-6. Because of the lack of mineralization and processing, the assumption presented in the Combined FSAP was that the concentrations of metals and radionuclides would be lower than the other areas of OU-5, and that sampling sufficient to support characterization and a risk assessment would be required to substantiate and document the assumption. This assumption was part of the background information used to develop the DQOs that guided the investigation described in Section 5.3.

As presented in the Combined FSAP, the primary sources of potential metals and radionuclides are soils/solids, and the primary release mechanisms are particles/dust and storm water runoff. Materials comprising the South WRA were evaluated as potential cover material for other parts of the ACMS so excavation and removal of a portion of the materials may be part of a future remedy.

5.2.2 Potential Transport Pathways

This section addresses the potential transport pathways through which COIs could be dispersed in the environment. The ACMS site-wide CSM included a general discussion of transport mechanisms for the waste rock piles (BC, 2009a). In conjunction with the primary release mechanisms described in Section 5.2.1., the transport pathways evaluated for the South WRA consist of:

- Transport by water erosion/surface water runoff
- Leaching/percolation to subsurface soil
- Transport to groundwater
- Transport by wind erosion

Each of these potential transport pathways are discussed further in Section 5.7.

5.3 Recent Remedial Investigation Summary

This section describes the DQOs, and the types of information used to characterize OU-5, specifically information collected during the recent OU-5 South WRA investigation performed in 2019-2020. The OU-5 investigation was performed in accordance with the approved Combined FSAP (Wood, 2019) and the ACMS Site-Wide QAPP (ARC, 2018). Previous investigations are described in Section 5.1.

5.3.1 Data Quality Objectives

DQOs for the recent OU-5 investigation were developed to facilitate the collection of reliable data for decision-making by the project-management team. A systematic seven-step planning approach was used as outlined in the U.S. EPA quality assurance document Guidance on Systematic Planning Using the Data Quality Objective Process (U.S. EPA, 2006). DQOs for the recent OU-5 investigation were originally presented in the Combined FSAP (Wood, 2019). The first two steps (problem statement and goals of the study) are presented here for reference and have been slightly modified to indicate that sampling has been completed.

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5.3.1.1   Step 1: State the Problem

Problem Statement 1: Chemistry data for materials in OU-5 are not sufficient to define the magnitude or spatial distribution of ACMS site-related COI concentrations necessary to support the RI and risk assessments.

Problem Statement 2: The physical and chemical properties of the waste rock in OU-5 South WRA are not sufficiently characterized for the purposes of deciding whether the materials in OU-5 may be suitable for future use as cover material. This study also will fill data gaps that will be used to support evaluation of South WRA materials for use as cover.

5.3.1.2   Step 2: Identify the Goals of the Study

The primary goal of the study is to generate data of acceptable quality on concentrations of COIs in materials placed in OU-5. The data will be used to complete the RI/FS, which includes conducting assessments of risk to human and ecological receptor populations and evaluating the acceptability for use as a cover material.

Study Question No. 1: Are the lateral and vertical extent of COI concentrations in OU-5 materials sufficiently characterized for the purposes of RI/FS assessment of impacted media, identification of potential physical transport mechanisms, assessment of potential risk to human and ecological receptors, or support evaluation of remedial alternatives?

Alternative outcomes:

1. The lateral and vertical extent of COI concentrations in OU-5 are sufficiently characterized. Additional sampling is not required. RI/FS and risk evaluations, and remedial alternative assessments may proceed.

2. The lateral and vertical extent of COI concentrations in OU-5 are not sufficiently characterized. Additional samples must be collected, analyzed, and evaluated before RI/FS and risk evaluations, or remedial alternative assessments may proceed.

Decision Statement No. 1: Using results from previous and recent samples, determine whether representative COI concentrations in the waste rock materials in OU-5 are sufficient to proceed with RI and risk evaluations, or remedial alternative assessments. Dataset sufficiency will be evaluated based on spatial and vertical coverage, comparison to background conditions, and consideration of variability with the COI datasets.

Study Question No. 2: Are the physical and chemical characteristics of the waste rock materials comprising the South WRA suitable for future use as cover material in other parts of the ACMS?

Alternative Outcomes:

1. The physical and chemical characteristics of the waste rock materials comprising the South WRA are suitable for future use as cover materials.

2. The physical and chemical characteristics of the waste rock materials comprising the South WRA are not suitable for future use as cover materials.

Decision Statement No. 2: Using results from previous and recent samples, determine whether the physical properties and COI concentrations in the South WRA waste rock would permit use as future cover material; otherwise, the material is unsuitable as future cover material.

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5.3.2   OU-5 South WRA Investigation

The South WRA was sampled in 2019-2020 as part of the investigation described in the Combined FSAP (Wood, 2019). The scope of the investigation consisted of the collection of soil samples from 32 shallow and three deep boreholes drilled in the South WRA. In order to provide a statistically valid dataset for the RI and risk assessments, soil samples were collected at a total of 35 randomly selected locations from the South WRA. For the shallow boreholes, sampling was performed at four discrete intervals, described in more detail in Section 5.3.2.2, to a total depth of approximately 15 feet bgs. The three deep boreholes were advanced through the waste rock pile to native soil. Once the native soil interface was encountered, boreholes were advanced an additional 20 feet in order to characterize the vertical and lateral variability of geochemical concentrations as well as potential impacts to the underlying native soil. The total explored depths of the deep boreholes varied and were decided in the field based upon the observed contact between the waste rock and underlying native soil. Additional details about the methods and procedures used during the investigation are presented in the following sections.

5.3.2.1   Drilling

Drilling activities began on December 16, 2019 and concluded on January 27, 2020. Borehole locations WRSB-206 through WRSB-240 were drilled in the South WRA as shown on Figure 5-1. Deep boreholes (WRSB-206 through WRSB-208) were advanced to 202, 166.4, and 153.5 feet bgs, respectively. Shallow boreholes (WRSB-209 through WRSB-240) were advanced to a total depth of approximately 15 feet bgs.

Sonic drilling methods were used for borehole advancement and sampling in accordance with SOP 103 – Drilling, Monitoring Well Installation, and Development. Sonic drilling produces a near continuous core over the entire length of the borehole. Drilling activities were performed by Cascade Drilling, LP of West Sacramento, California. Soil samples were collected using an approximately 6-inch or 4-inch diameter core barrel. Material collected inside the core barrel was extruded into plastic bags that were tied at one end and given to the field geologist for logging and sampling. Samples were collected from each bagged sample interval at the desired depth. During drilling, each borehole was advanced and temporarily cased to its total depth using approximately 6-inch drill casing as coring activities were being performed. Core barrels and drill casing were decontaminated prior to their use at each borehole location in accordance with SOP 201 – Equipment Decontamination. The boreholes were continuously logged and described using the USCS in accordance with SOP – 305 Field Classification of Soil. Borehole logs are presented in Appendix 5C. Over 95% of the materials observed during drilling consisted of poorly graded gravel with sand and poorly graded sand with gravel. These materials contained relatively high amounts of gravel (approximately 50% to 90%) and sand (approximately 50% to 90%) and low amounts of fines (approximately trace amounts to 10%).

Samples were transferred into a combination of laboratory-supplied sample containers, zip top bags, and 2-gallon plastic buckets, depending on the analytical requirements at each sampling interval. Sample collection is further described in the following section and was performed in accordance with SOP 304 – Soil Sampling. Drill core remaining after sample collection was placed into labeled core boxes and photographed. After drilling, shallow boreholes were backfilled with hydrated bentonite chips. The deep boreholes were backfilled with bentonite cement grout to approximately 40 feet above the total depth followed by hydrated bentonite chips to ground surface. Backfilling was conducted in general accordance with SOP 104 – Borehole and Monitoring Well Plugging.

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5.3.2.2 Sampling

As described in the Combined FSAP (Wood, 2019), all samples collected from the shallow boreholes (WRSB-209 through WRSB-240) and the uppermost 15 feet of the deep boreholes (WRSB-206 through WRSB-208) were collected from four depths:

- a discrete sample from approximately 0 to 0.5 feet bgs;
- a composite sample from approximately 0.5 to 3 feet bgs;
- a composite sample from approximately 3 to 6 feet bgs;
- and a composite sample from approximately 6 to 15 feet bgs.

At the deep boreholes, additional composite samples were collected over approximately 10-feet intervals below 15 feet to the depth of the native soil interface. Two samples were collected in the underlying native soil at 5 to 10 feet and 15 to 20 feet beneath the native soil interface. Sampling depths and the number of samples collected within the deep boreholes were decided in the field based upon the observed contact between the waste rock and the underlying native soil. Sample intervals are shown on the borehole logs presented in Appendix 5C. Prior to being placed in sample containers, the material to be sampled was placed in a decontaminated stainless-steel mixing bowl, homogenized, then placed in the appropriate sample container in accordance with SOP 304 – Soil Sampling.

5.3.2.3 Laboratory Analysis

After collection, samples were labeled, and either placed into an ice-cooled chest or other containers as appropriate for the analytical method and transported to the laboratory under chain-of-custody protocol.

All samples collected from the South WRA were analyzed for the following parameters:

- Metals[2] analysis by TestAmerica of Irvine, California
- Radionuclides (radium-226 and radium-228) analysis by TestAmerica of St. Louis, Missouri

Samples collected from a subset of depths were analyzed for the following parameters:

- ABA/NAG analysis by ACZ
- MWMP extraction, and analysis of the MWMP extract for metals, anions (chlorine, fluorine, nitrate and nitrite (as N), and sulfate), TKN (as N), TDS, pH, alkalinity, and radium-226 and radium-228) by ACZ

Table 4-1 presents the analytes and analytical methods from the investigation.

5.3.2.4 Data Quality Summary Report

QA/QC program presented in the Site-Wide QAPP outlines the field and laboratory QA/QC measures for obtaining data, which includes adhering to acceptable test methods and SOPs, following chain-of-custody protocols, collecting of field QC samples at the required frequency, evaluating QC samples for precision and accuracy of field and laboratory methods, and completing data review processes.

Appendix 5D contains the Data Quality Summary Report (Appendix 5D-1) which includes the outcome for data usability, results of field quality control samples, and data validation findings for the 2019-2020

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[2] Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorous, potassium, selenium, silver, sodium, strontium, thallium, thorium, tin, titanium, uranium, vanadium, and zinc.

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South WRA investigation. The Data Quality Summary Report concludes that more than 98 percent of the planned data were completed and deemed available for use as quantitative data. Laboratory analytical reports are provided in Appendix 5D-2. Data validation reports prepared by the third-party data quality reviewer, Environmental Standards, Inc., for chemical results are provided in Appendix 5D-3. A database output of the 2018 and 2019-2020 investigations is provided in Appendix 5D-4.

5.4   Stratigraphy and Hydrogeology

Stratigraphic and hydrogeologic information specific to the South WRA are presented here and are in support of the discussion of transport pathways provided in Section 5.7.2. This section focuses on the stratigraphy and hydrogeology of the South WRA, discussions of W-3 and S-23 are presented in the OU-8 PA RI/FS and are summarized below in Section 5.8. Figures 5-2 and 5-3 show the South WRA lithology based on the recent 2018 and 2019-2020 investigations. The thickness of the South WRA material ranged from approximately 131.5 feet to 182 feet. The native soil contact beneath the South WRA generally slopes from west to east. In terms of elevations, the native soil beneath the South WRA ranges from approximately 4,450 feet amsl to 4,526 feet amsl. The 2019 shallow groundwater elevations in the vicinity of the South WRA ranged from approximately 4,327.6 feet amsl to 4,328.04 feet amsl, suggesting that there is a large vadose zone of approximately 120 to 200 feet beneath the bottom of the waste rock.

With regards to the South WRA, 2019 shallow aquifer groundwater levels ranged from approximately 301.68 to 302.12 feet bgs (4,328.04 to 4,327.6 feet amsl) in PLMW-4S. Only a small portion of the shallow aquifer underlies the far eastern and far western portions of the South WRA, the water table beneath much of the pile is generally in the bedrock (Wood, 2020d). The 2019 groundwater levels in bedrock monitoring wells near the base of the South WRA (PLMW-3RB and PLMW-4B) ranged from 253.24 to 316.45 feet bgs (4,244.48 to 4,313.27 feet amsl). Bedrock groundwater flow potential under these areas is generally to the north, toward the pit (Wood, 2020f).

5.5   Data Quality Assessment

An assessment of data quality is provided in this section, for the data collected in 2010, as well as the data from the 2018 and 2019-2020 investigations.

5.5.1   2010 Investigation

2010 characterization of potential cover materials data have already been reported previously as presented in Section 5.1.3. The 2010 data presented in this RI are supported by U.S. EPA approved Site work plans, rigorous sampling and analysis procedures, QA/QC protocols, and documentation requirements.

DQOs for the 2010 characterization of potential cover materials investigation are presented in the *Cover Materials Characterization Work Plan, Revision 2* (Cover Materials Work Plan) (BC, 2010b). Data quality for the 2010 cover materials data (Section 5.1.3) were originally presented in the Cover Materials DSR (ARC, 2011). As presented in the report, sample results met the DQOs and all data are considered usable.

In summary, all laboratory data from 2010 met the DQOs and QAPP requirements and were considered usable for this RI and the forthcoming HHRA and SLERA.

5.5.2   2018 and 2019-2020 Investigations

This section describes the DQA performed for the data collected for the South WRA from 2018 and 2019-2020 (locations WRSB-201 through WRSB-240). A DQA for data collected for the evaluation of W-3 and S-23 has been presented in the OU-8 PA RI/FS. As presented in that document, the data set evaluated in the OU-8 PA RI/FS was of adequate quality for the intended purpose defined in the DQOs for W-3 and S-23.

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Because the 2018 and 2019-2020 data comprise the main dataset used in the remainder of this RI, the DQA for the South WRA presented here includes both a qualitative and quantitative evaluation of the data to determine if the data are of the right type, quality, and quantity to support the study decisions. The DQA provides an assessment of the data usability, determines if the data set is complete, and decides whether the data can be used to support characterization of the nature and extent of COIs, risk assessments, and other evaluations.

This DQA is performed on an iterative basis as planned data become available (i.e., after sample collection and analytical data quality control reviews are complete) to determine whether the project-specific DQOs are satisfied. The DQA consists of five steps that relate the quality of the results to the intended use of the data (U.S. EPA, 2006). The five steps of the DQA process are:

- Step 1: Review of DQOs and Sampling Design

- Step 2: Conduct a Preliminary Data Review

- Step 3: Select the Statistical Method

- Step 4: Verify the Assumptions of the Statistical Method

- Step 5: Draw Conclusions from the Data.

The status of the data quality assessment for the South WRA in relation to the five steps in the DQA process is summarized in the following sections.

5.5.2.1 Step 1: Review of DQOs and Sampling Design

This step in the DQA process was completed through the review of DQOs developed for the South WRA. The Combined FSAP (Wood, 2019) presented DQOs for the South WRA, which are also summarized in Section 5.3.1. As demonstrated in this document, the DQOs were met for the South WRA. The overall project objectives for South WRA were to collect additional characterization data needed to evaluate risk to human and ecological receptors. Additionally, an objective was to characterize the South WRA such that an evaluation may be made in a subsequent document (i.e., the risk assessment or feasibility study) on the suitability for future use as cover material

5.5.2.2 Step 2: Preliminary Data Review

This step included the review of quality assurance reports for the validation of data, the calculation of basic statistics using the data, and the evaluation of data using graphical techniques. Data evaluated in this document are supported by work plans, rigorous sampling and analysis procedures, QA/QC protocols, and documentation requirements.

Data quality results for the South WRA are presented in Section 5.3.2.4. In general, the South WRA data presented in this document were deemed acceptable for evaluation.

The following assumptions were applied when using the qualified data for the evaluation of chemical data:

- Estimated values were retained and used as reported for the analysis of the spatial distribution of various sampling results on maps, cross sections, and other report graphics. Laboratory results reported as non-detect were represented at the non-detect value for these spatial analyses.

- Only results from primary samples were used for the presentation and evaluation of chemical data. Results for field duplicate samples are retained in the database, but they were not used during data evaluation in compliance with the QAPP. An evaluation of field duplicate samples is presented in the DQSR in Appendix 5D-1.

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For the South WRA data, another component of the preliminary data review is exploratory data analysis of certain chemistry parameters. The approach varies based on the type of data collected, but it typically includes tabulating and plotting the data, performing statistical tests to evaluate if the data represent one or more populations, and calculating descriptive statistics. All available South WRA data were found to be valid for inclusion in these preliminary data review methods as discussed in the sections below. Tabulated summary statistics and graphical presentation of the data are provided in Section 5.6.

5.5.2.3   Step 3: Select the Statistical Method

South WRA data were used to make comparisons of metal concentrations between the depth intervals and material types. The ProUCL Version 5.1 (U.S. EPA, 2015) Goodness-of-Fit test was used to evaluate the population distribution of metals data for the South WRA. The analytical data used for testing are provided in Appendix 5E. The best fit distribution varied by metal and by material type with some of the metals following no distribution. Therefore, when comparing data populations and conducting hypothesis tests, a non-parametric test (Gehan or Wilcoxon-Mann-Whitney test) that does not assume a statistically significant distribution was used. For results reported as non-detect, these statistical methods use the non-detect value in the calculation.

5.5.2.4   Step 4: Verify the Assumptions of the Statistical Method

A key assumption when using parametric statistical tests is that the data follow a normal distribution. Data from the South WRA are summarized in Tables 5-1 through 5-4 and are presented in their entirety in Appendix 5E. Parametric tests have a greater difficulty dealing with outliers and non-detects than their nonparametric counterparts. As stated in the previous section, much of the metals data did not follow a normal distribution; therefore, nonparametric tests were employed for hypothesis testing. Another key assumption for both parametric and nonparametric tests is data independence. Two departures from data independence are commonly encountered: serial patterns in data collection (autocorrelation) and clustering (clumping) of data. Based on the sampling design, autocorrelation and clustering were not expected to occur. The assumptions of the statistical tests used are met; therefore, the tests are appropriate for evaluating the data.

5.5.2.5   Step 5: Draw Conclusions from the Data

Section 5.6 presents an overview of the analytical results for the South WRA, including tabulated summary statistics. Conclusions drawn from the data, including those based on statistical hypothesis testing, are presented in Sections 5.6 and 5.8.

5.5.2.6   Data Quality Summary

The data set evaluated in this document is of adequate quality for the intended purpose defined in the DQOs and is acceptable for use in this RI and the forthcoming HHRA and SLERA. Exploratory data analysis indicated the data were not normally distributed; therefore, nonparametric statistical tests were used to evaluate the data. The assumptions of the hypothesis tests were verified, and the conclusions drawn from those tests are discussed in Sections 5.6 and 5.8.

DQOs were established in the Combined FSAP (Wood, 2019) and have been presented again in Section 5.3.1. The problem statements identified the need for additional characterization data, which has been collected as described in Section 5.1.5 and 5.3.2. Section 5.6 describes how these data adequately characterize the nature and extent of contamination. Additionally, Section 5.7 describes the characterization related to contaminant fate and transport. As a result of this presentation and evaluation, the DQOs for OU-5 established in the Combined FSAP (Wood, 2019) have been met.

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5.6   Nature and Extent of Contamination

This section presents the nature and extent of contamination for the South WRA, mainly utilizing the data collected from 2018 through 2020, although the 2010 cover materials dataset is also used for comparative purposes. The nature and extent of contamination for W-3 and S-23 have previously been presented in the OU-8 PA RI/FS (Wood, 2020a). However, where applicable, information from W-3 and S-23 and how they relate to the South WRA are included in this section. In addition, a summary of the relevant conclusions from W-3 and S-23 are presented in this document along with the conclusions from the South WRA in Sections 5.8 and Section 8.0.

5.6.1   Constituents of Interest

The samples from the South WRA were analyzed for various analytes as specified in the approved Combined FSAP (Wood, 2019). Although all data are presented in this RI (Appendix 5E), a subset of the analytes is used to focus the discussion of nature and extent and fate and transport of contaminants. The subset of analytes is referred to as COIs in this report and were selected to allow for a concise discussion of the general trends seen in the data. The selection of this subset is not intended to replace the screening process in the future HHRA and SLERA. Screening and evaluation of all analytes will be addressed in the future HHRA and SLERA, which will result in the identification of COPCs and COPECs.

The South WRA data were evaluated against BCLs. In this RI, the soil COIs are compared to BCLs as developed in the Background Soils DSR (BC, 2009b). As proposed in the Background Soils DSR, Sub-Area A-2 BCLs are considered the most applicable BCL to OU-5 (which contains the South WRA). Sub-Area A-2 is in part composed of soils derived from mineralized granitic rocks. The granitic rocks have been subject to large scale alteration and mineralization as evidenced by the several large, known, porphyry copper deposits in the district, including the ACMS ore body. However, comparisons using these BCLs should take into account that the South WRA is composed of alluvial material and waste rock overlying the ACMS ore body; whereas, Sub-Area A-2 is composed only of soil derived from mineralized rock that has been subject to past weathering, erosion, transport and deposition in an alluvial fan system As such, the South WRA would be predisposed to contain higher concentrations of metals because of its proximity to the ACMS ore body and the relatively low amount of weathering that has occurred compared to the Sub-Area A-2 soils.

The COIs identified and evaluated were based on elevated concentrations of analytes that were above the respective BCLs following these criteria:

- Analytes detected above their respective BCL in more than 10% of the sample population were retained as COIs. The cut off value of 10% was chosen after reviewing the data and using professional judgement so that the evaluation could be focused on those analytes that more regularly exceeded their respective BCL.

- Analytes detected above their respective BCL in less than 10% of the sample population were not retained as COIs

- Analytes that were not detected in any sample above the laboratory reporting limit were not retained as COIs

- Analytes with no BCL (lithium, phosphorus, strontium, tin, and titanium) were not retained as COIs

Following these criteria, the soil analytes identified as COIs and evaluated in the RI consist of:

- Metals: copper, mercury, molybdenum, selenium, and uranium

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- Radionuclides: radium-226 and radium-228 (radium-228 did not meet the criteria of being detected in more than 10% of the sample population, but is retained as a COI at NDEP request)

The COIs identified in this section are the focus of the nature and extent of contamination and fate and transport evaluations in this section and in Section 5.7, respectively. The discussions of these COIs are supported by map view figures, cross-sections, and graphs presented in figures referenced throughout the following sections.

5.6.2   South WRA Material Types

The COIs identified in the previous section were used to perform exploratory data analysis (EDA) on the South WRA data. As described in Section 2.2.2, there are likely two types of materials (alluvial material and waste rock) that make up the mine-related material in the South WRA. Unlike the VLT and sulfide tailings seen in OU-4b, the South WRA mine-related materials observed during sampling did not lend themselves to visual distinction between alluvium and waste rock. Furthermore, mining of the pit occurred in a multi-step process where during its operational period the pit was expanded to the north (as shown in the aerial photographs in Appendix 2B). As such, alluvial material was excavated at different time periods during mining, causing the South WRA to have alluvial material present inconsistently in different depth intervals and lateral areas. To account for the apparent intermixing of alluvium and waste rock, during the EDA, the possibility of multiple populations was explored in part by using Q-Q plots. Based on the plots, several of the COIs showed a bimodal distribution. Q-Q plots for all metals are presented in Appendix 5F, and the plots for copper, molybdenum, selenium, uranium, and radium-226 suggest that these COIs follow a bimodal distribution.

To supplement the Q-Q plots, box plots for the COIs were prepared showing the different material types seen in the South WRA (Figures 5-4 through 5-7). In addition to the South WRA materials, the corresponding concentrations in the other waste rock piles, W-3 and S-23 are shown on the box plots as well. To reflect the bimodal nature of the South WRA data, the samples from within the pile were segregated into two categories, alluvium and waste rock. The segregation between alluvium and waste rock was based on copper concentrations, where samples with concentrations over the BCL were considered waste rock, and those with concentrations below the BCL were considered alluvium. From this classification, approximately two thirds of the mine-related material samples is classified as alluvium and one third is classified as waste rock. Also shown on the box plots are the sample collected from the native soil beneath the pile. While there is some uncertainty in using the BCL to segregate material types, this segregation was done for the purposes of the RI in order to follow the bimodal distributions seen in the data, and to assess the nature of the materials in the South WRA. These classifications are considered empirical and are based on the information presented in this document and are intended to be used for the RI. Their use in any future risk assessments, FS, or RD/RA activities may be limited.

The box plots support the observation from the Q-Q plots of a bimodal distribution and suggest that the evaluation in the RI for the South WRA can differentiate the mine-related material into alluvium and waste rock designations. When looking at the IQR and CV, some variability is present in COI concentrations. However, for most COIs the IQRs and CVs for each material type are generally similar or less than the CV when all the materials are combined (Table 5-1). As discussed in Section 4.6.2, while the CV is relative to the mean rather than the median, it can still be used along with the IQR as a supporting evaluation, while recognizing there may be some uncertainty in its use. The IQR and the CV, along with the box plots suggest that there is lower data variability within each material type, and that, for the purposes of the RI, it is appropriate to evaluate the material types separately. For the remainder of this document, these categories are used in data evaluation.

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5.6.3   Metals and Radionuclide Results

Table 5-1 summarizes soil metal and radionuclide statistics from the South WRA analytical results. Table 5-1 presents statistics for COIs for all samples and material types combined together, as well as statistics separated by material type (alluvium, waste rock, and native soil, as described in Section 5.6.2). The tables provide: 1) the number of observations, detections, detection frequency, minimum, maximum, mean, median, CV, 25th percentile, 75th percentile, and IQR of all analyzed metals and radionuclides; 2) corresponding Sub-Area A-2 BCLs as described in Section 5.6.1; and 3) percent of observations that exceed these BCLs. A summary of COIs for the South WRA is described in more detail below.

COI concentrations generally do not follow consistent lateral trends throughout the South WRA, which likely is a result of the mechanical placement of the materials during mining operations. The spatial distribution of waste rock and alluvium, and therefore COIs, varies throughout the South WRA. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, and radium-228.

Two-sample hypothesis testing was performed using ProUCL Version 5.1 (U.S. EPA, 2015) to assess vertical trends and COI differences between the four different depth intervals (0 to 0.5, 0.5 to 3, 3 to 6, and 6 to 15 feet bgs) in the upper 15 feet at locations WRSB-206 though WRSB-240. Based on the testing, the four depth intervals areas have statistically equivalent concentrations of all COIs, suggesting that there is limited variability by depth in the upper 15 feet of the South WRA. Results of the testing are presented on Table 5-5. ProUCL software output data are presented in Appendix 5G.

In the South WRA, COI concentrations are generally within one to two orders of magnitude of one another. Table 5-6 presents a comparison of COI results between the 2018 and 2019-2020 data and the 2010 Potential Cover Materials Evaluations. Comparisons show that between the two investigations the median values of COIs are similar. As described in Section 5.1.3, the 2010 investigation included samples that were whole rock samples. In addition, a subset of the rock samples specifically targeted to represent rocks displaying a high degree of mineralization. These samples would be expected to contain higher concentrations of COIs when compared to the 2018 and 2019-2020 investigation, where no such targeting of mineralized rocks took place. As a result, some of the maximum concentrations from the 2010 investigation are higher than those from the 2018 and 2019-2020 investigation. Nevertheless, the overall consistency between the two investigations suggests that the observed ranges in concentrations represent the overall nature of the waste rock.

5.6.3.1   Individual COI Results

The soil COI geochemical trends are plotted on maps and cross-sections using a consistent color-coding scheme (Figure 5-8 through Figure 5-28). Concentrations at or below the applicable BCL are shown in green. Concentrations between the BCL and 10 times the BCL are shown in yellow. Concentrations between 10 times the BCL and 100 times the BCL are shown in orange. The intent of the color-coding scheme is to help the reader visualize spatial variations in the COI concentrations. Cross-section locations are shown on Figure 5-1.

Complete COI results as well as the results for other metals and radionuclides not identified as COIs are presented in Appendix 5E. Discussion of the spatial and vertical distribution of each COI is provided below. For comparative purposes and as described in Section 5.6.2, the discussion of each COI is divided into three parts: waste rock, alluvium, and native soil material. Native soil material was collected from boreholes that were advanced beyond the bottom of the South WRA at three locations (WRSB-206, WRSB-207, and WRSB-208). In total, 227 samples were collected across 40 field locations (WRSB-201 through WRSB-240) on the South WRA. Of these samples, 70 were waste rock, 151 were alluvium, and six were native soil. In terms of locations, 10 contained only waste rock, 23 contained only alluvium, and

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seven contained a mixture of waste rock and alluvium. As described further in Section 5.6.2, the classification of materials was performed to explain the bimodal data distribution observed, and for describing the overall nature of the South WRA material.

Copper: The distribution of copper is shown on Figures 5-8 through 5-10, and summarized as follows:

- Copper concentrations in alluvium ranged from 9.6 to 280 mg/kg. The maximum copper concentration was detected at two locations, WRSB-203 and WRSB-207 at depths of 100 to 110 feet bgs and 15 to 25 feet bgs, respectively. No alluvium sample concentrations were above the copper BCL of 285 mg/kg.

- Copper concentrations in waste rock ranged from 310 to 3,200 mg/kg. The maximum copper concentration was detected at two locations, WRSB-216 and WRSB-224 at depths of 0 to 0.5 feet bgs and 3 to 6 feet bgs, respectively. Waste rock samples from all 17 locations that had sample intervals containing only waste rock had concentrations above the copper BCL of 285 mg/kg.

- Copper concentrations in native soil material ranged from 28 to 160 mg/kg. The maximum copper concentration was detected at location WRSB-208 at a depth of 136.5 to 141.5 feet bgs. No native soil sample concentrations were above the copper BCL of 285 mg/kg.

Copper concentrations are higher in the waste rock than in the alluvium and native material types (Figure 5-4). Copper concentrations in the waste rock and alluvium are generally consistent by location, such that for many locations, concentrations are similar with depth (Table 5-5). Approximately 30% of copper concentrations from all waste rock and alluvium samples exceed the BCL (as described in Section 5.6.2, these 30% are considered apparent waste rock and the remainder are considered apparent alluvium). The highest concentrations of copper generally occur in the central portion of the South WRA (Figure 5-8). When compared to the other waste rock piles (Figure 5-4), copper concentrations from the waste rock in the South WRA are similar to those observed in W-3 and are less than those observed in S-23.

Mercury: The distribution of mercury is shown on Figures 5-11 through 5-13, and summarized as follows:

- Mercury concentrations in alluvium ranged from not detected (less than 0.012 mg/kg) to 0.25 mg/kg. The maximum copper concentration was detected WRSB-205 at a depth of 70 to 80 feet bgs. Seven of 40 sample locations had at least one alluvium sample with a concentration above the mercury BCL of 0.05 mg/kg.

- Mercury concentrations in waste rock ranged from not detected (less than 0.012 mg/kg) to 2.5 mg/kg. The maximum mercury concentration was detected at location WRSB-229 at a depth of 6 to 15 feet bgs. Fourteen of 40 sample locations had at least one waste rock sample with a concentration above the mercury BCL of 0.05 mg/kg.

- Mercury concentrations in native soil materials ranged from not detected (less than 0.012 mg/kg) to 0.015 mg/kg. The maximum mercury concentration was detected at location WRSB-208 at a depth of 136.5 to 141.5 feet bgs. No native soil sample concentrations were above the mercury BCL of 0.05 mg/kg.

Mercury concentrations follow similar trends to other COIs, in that concentrations are higher in the waste rock than in the alluvium and native material types (Figure 5-4). Mercury concentrations in waste rock and alluvium are generally consistent by location and tend to be similar with depth (Table 5-5). Approximately 30% of mercury concentrations from all waste rock and alluvium samples exceed the BCL. The highest concentrations of mercury generally occur in the northeastern portion of the South WRA (Figure 5-11). When compared to the other waste rock piles (Figure 5-4), mercury concentrations from the waste rock in the South WRA are less than those observed in W-3 and S-23.

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Molybdenum: The distribution of molybdenum is shown on Figures 5-14 through 5-16, and summarized as follows:

- Molybdenum concentrations in alluvium ranged from not detected (less than 0.51 mg/kg) to 22 mg/kg. The maximum molybdenum concentration was detected at location WRSB-228 at depths of 0.5 to 3 feet bgs and 3 to 6 feet bgs. Seven of 40 sample locations had at least one alluvium sample with a concentration above the molybdenum BCL of 3.3 mg/kg.

- Molybdenum concentrations in waste rock ranged from not detected (less than 1 mg/kg) to 36 mg/kg. The maximum molybdenum concentration was detected at location WRSB-220 at a depth of 6 to 15 feet bgs. Thirteen of 40 sample locations had at least one waste rock sample with a concentration above the molybdenum BCL of 3.3 mg/kg.

- Molybdenum concentrations in native soil materials ranged from 0.56 to 11 mg/kg. The maximum molybdenum concentration was detected at location WRSB-206 at a depth of 187 to 192 feet bgs. This sample exceeded the molybdenum BCL of 3.3 mg/kg. The remaining five native soil samples did not exceed the molybdenum BCL.

Molybdenum concentrations follow similar trends to other COIs, in that concentrations are higher in the waste rock than in the alluvium and native material types, although there is some overlap between waste rock and alluvium concentrations (Figure 5-5). Molybdenum concentrations in the waste rock and alluvium are generally consistent by location and tend to be similar with depth (Table 5-5). Approximately 30% of molybdenum concentrations from all waste rock and alluvium samples exceed the BCL. Spatially, the highest concentrations of molybdenum generally occur in the central and northern portions of the South WRA (Figure 5-14). When compared to the other waste rock piles (Figure 5-5), molybdenum concentrations from the waste rock in the South WRA are generally higher than those observed in W-3 and S-23.

The native soil sample from WRSB-206 that exceeded the BCL is underlain by a deeper native soil sample which did not exceed the BCL. Additionally, no sample in approximately 65 feet of waste rock and alluvium overlying the native soil exceeded the BCL.

Selenium: The distribution of selenium is shown on Figures 5-17 through 5-19, and summarized as follows:

- Selenium concentrations in alluvium ranged from not detected (less than 0.41 mg/kg) to 6.8 mg/kg. The maximum selenium concentration was detected at WRSB-233 at a depth of 3 to 6 feet bgs. Twenty-seven of 40 sample locations had at least one alluvium sample with a concentration above the selenium BCL of 0.87 mg/kg.

- Selenium concentrations in waste rock ranged from 0.47 mg/kg to 10 mg/kg. The maximum selenium concentration was detected at location WRSB-206 at a depth of 3 to 6 feet bgs. Sixteen of 40 sample locations had at least one waste rock sample with a concentration above the selenium BCL of 0.87 mg/kg.

- Selenium concentrations in native soil ranged from 0.84 to 1.7 mg/kg. The maximum selenium concentration was detected at location WRSB-208 at a depth of 146.5 to 151.5 feet bgs. All native soil samples at WRSB-207 and WRSB-208 exceeded the selenium BCL of 0.87 mg/kg. Both native soil samples at WRSB-206 were below the selenium BCL.

Selenium concentrations follow similar trends to other COIs, in that concentrations are higher in the waste rock than in the alluvium and native material types, although there is some overlap between waste rock and alluvium concentrations (Figure 5-5). Selenium concentrations above the BCL occur more frequently than other COIs, with approximately 80% of concentrations from all waste rock and alluvium samples

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exceeding the BCL. The highest concentrations of selenium generally occur in the southeastern portion of the South WRA (Figure 5-17). When compared to the other waste rock piles (Figure 5-5), selenium concentrations from the waste rock in the South WRA are similar to those observed in W-3 and are less than those observed in S-23.

Uranium: The distribution of uranium is shown on Figures 5-20 through 5-22, and summarized as follows:

- Uranium concentrations in alluvium ranged from 0.75 to 13 mg/kg. The maximum uranium concentration was detected at WRSB-207 and WRSB-227 at depths of 15 to 25 feet bgs and 0 to 0.5 feet bgs, respectively. Six of 40 sample locations had at least one alluvium sample with a concentration above the uranium BCL of 4.1 mg/kg.

- Uranium concentrations in waste rock ranged from 1.1 to 21 mg/kg. The maximum uranium concentration was detected at location WRSB-206 at a depth of 6 to 15 feet bgs. Twelve of 40 sample locations had at least one waste rock sample with a concentration above the uranium BCL of 4.1 mg/kg.

- Uranium concentrations in native soil material ranged from 0.97 to 1.5 mg/kg. The maximum uranium concentration was detected at location WRSB-208 at a depth of 136.5 to 141.5 feet bgs. No native soil sample concentrations were above the uranium BCL of 4.1 mg/kg.

Uranium concentrations follow similar trends to other COIs, in that concentrations are higher in the waste rock than in the alluvium and native material types, although there is some overlap between waste rock and alluvium concentrations (Figure 5-6). Uranium concentrations in the waste rock and alluvium are generally consistent by location, such that for many locations the shallow concentrations in the upper 15 feet are similar with depth (Table 5-5). For deeper samples, concentrations generally decrease with depth or are consistently below the BCL. Approximately 20% of uranium concentrations from all waste rock and alluvium samples exceed the BCL. The highest concentrations of uranium generally occur in the central to southeastern portion of the South WRA (Figure 5-20). When compared to the other waste rock piles (Figure 5-6), uranium concentrations from the waste rock in the South WRA are higher than those observed in W-3 and S-23.

Radium-226: The distribution of radium-226 is shown on Figures 5-23 through 5-25, and summarized as follows:

- Radium-226 concentrations in alluvium ranged from not detected (less than 0.581 pCi/g) to 3.27 pCi/g. The maximum radium-226 concentration was detected at WRSB-227 at a depth of 0 to 0.5 feet bgs. Five of 40 sample locations had at least one alluvium sample with a concentration above the radium-226 BCL of 2.44 pCi/g.

- Radium-226 concentrations in waste rock material ranged from 0.816 to 9.92 pCi/g. The maximum radium-226 concentration was detected at location WRSB-206 at a depth of 3 to 6 feet bgs. Eleven of 40 sample locations had at least one waste rock sample with a concentration above the radium-226 BCL of 2.44 pCi/g.

- Radium-226 concentrations in native soil material ranged from 0.944 to 1.43 pCi/g. The maximum radium-226 concentration was detected at location WRSB-207 at a depth of 140 to 145 feet bgs. No native soil sample concentrations were above the radium-226 BCL of 2.44 pCi/g.

Radium-226 concentrations follow similar trends to other COIs, in that concentrations are higher in the waste rock than in the alluvium and native material types, although there is some overlap between waste rock and alluvium concentrations (Figure 5-7). Radium-226 concentrations in the waste rock and alluvium are generally consistent by location, such that for many locations, shallow concentrations in the upper 15 feet are similar with depth (Table 5-5). For deeper samples, concentrations generally decrease with depth

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or are consistently below the BCL. Approximately 15% of radium-226 concentrations from all waste rock and alluvium samples exceed the BCL. The highest concentrations of radium-226 generally occur in the central portion of the South WRA (Figure 5-23). When compared to the other waste rock piles (Figure 5-7), radium-226 concentrations from the waste rock in the South WRA are similar to those observed in W-3 and are higher than those observed in S-23.

Radium-228: The distribution of radium-228 is shown on Figures 5-26 through 5-28, and summarized as follows:

- Radium-228 concentrations in alluvium ranged from 0.576 to 3.43 pCi/g. The maximum radium-228 concentration was detected at WRSB-234 at a depth of 6 to 15 feet bgs. Nine of 40 sample locations had at least one alluvium sample with a concentration above the radium-228 BCL of 2.13 pCi/g.

- Radium-228 concentrations in waste rock material ranged from 0.72 to 2.36 pCi/g. The maximum radium-228 concentration was detected at location WRSB-207 at a depth of 3 to 6 feet bgs. Four of 40 sample locations had at least one waste rock sample with a concentration above the radium-226 BCL of 2.13 pCi/g.

- Radium-228 concentrations in native soil material ranged from 0.876 to 1.51 pCi/g. The maximum radium-226 concentration was detected at location WRSB-208 at a depth of 146.5 to 151.5 feet bgs. No native soil sample concentrations were above the radium-226 BCL of 2.13 pCi/g.

Radium-228 concentrations are generally higher in the alluvium than in the waste rock and native material types (Figure 5-7). Radium-228 concentrations in the waste rock and alluvium are generally consistent by location, such that for many locations, shallow concentrations in the upper 15 feet are similar with depth (Table 5-5). For deeper samples, concentrations generally decrease with depth or are consistently below the BCL. Approximately 10% of radium-228 concentrations from all waste rock and alluvium samples exceed the BCL.

5.6.4   MWMP Results

As previously discussed in Section 4.6.4.1, the MWMP method is generally used for simulating leaching in a surficial or near-surface waste rock environment and has less of a direct application for the subsurface soil environment. The results provide a general estimate of the relative mobility of COIs from the South WRA materials and will be utilized in the forthcoming SLERA. Estimates made using MWMP should be considered conservatively elevated because current conditions make saturation of subsurface materials rare or unlikely.

Summary statistics for MWMP metals and radionuclides results are presented in Table 5-2 and MWMP general chemistry results are presented in Table 5-3. As described in Section 5.3.2, MWMP samples were collected from select depth intervals from the boreholes in the South WRA. Concentrations of COIs were detected in the MWMP extract with uranium and molybdenum being detected most often followed by copper, selenium, radium-226, mercury, and radium-228. MWMP results are presented in Appendix 5E, and a summary of these results for the COIs identified above is provided below.

- **Copper:** MWMP copper concentrations ranged from 0.0011 mg/L to 574 mg/L, with the median of detected values at 0.0092 mg/L. In general, MWMP copper concentrations were higher in waste rock samples compared to alluvium samples (Table 5-2). MWMP copper was detected in 95% of MWMP samples, regardless of material type.

- **Mercury:** MWMP mercury concentrations ranged from not detected (less than 0.0001 mg/L) to 0.0005 mg/L, with the median of detected values at 0.00021 mg/L. MWMP mercury was detected

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in 5% of MWMP samples. MWMP mercury concentrations and detection frequencies were higher in waste rock samples compared to alluvium and native soil samples (Table 5-2).

- **Molybdenum:** MWMP molybdenum concentrations ranged from not detected (less than 0.002 mg/L) to 0.2 mg/L, with the median of detected values at 0.041 mg/L. MWMP molybdenum concentrations were higher in native soil samples compared to alluvium and waste rock samples (Table 5-2). MWMP molybdenum was detected in 98% of all MWMP samples, and detection frequencies between alluvium, waste, rock, and native soil were similar.

- **Selenium:** MWMP selenium concentrations ranged from not detected (less than 0.0001 mg/L) to 0.314 mg/L, with the median of detected values at 0.00075 mg/L. MWMP selenium concentrations were generally similar between alluvium, waste rock, and native soil samples (Table 5-2), however, a subset of waste rock samples had concentrations higher than the other material types. MWMP selenium was detected in 74% of MWMP samples, with waste rock and native soil samples having higher detection frequencies than alluvium samples.

- **Uranium:** MWMP uranium concentrations ranged from 0.0001 mg/L to 2.27 mg/L, with the median of detected values at 0.005 mg/L. MWMP uranium concentrations were higher in native soil samples compared to alluvium and waste rock samples (Table 5-2). Uranium was detected in 100% of MWMP samples, regardless of material type.

- **Radium-226:** MWMP radium-226 concentrations ranged from 0.32 pCi/L to 7.3 pCi/L, with the median of detected values at 0.82 pCi/L. Concentrations were generally similar between alluvium, waste rock, and native soil samples (Table 5-2). Radium-226 was detected in 47% of MWMP samples, with waste rock samples having higher detection frequencies than alluvium and native soil samples.

- **Radium-228:** MWMP radium-228 concentrations ranged from not detected (less than 0.723 pCi/L to 21 pCi/L, with the median of detected values at 5.8 pCi/L. Radium-228 was detected in 3% of MWMP samples and was not detected in any waste rock or native soil sample (Table 5-2).

- **pH:** MWMP pH values ranged from 3.3 to 9.5 pH units, with a median value of 8.7 pH units. pH values were generally higher in alluvium and native soil samples compared to waste rock samples (Table 5-3).

Uranium, molybdenum, and copper were the most often detected COIs in the MWMP samples from the South WRA. These three COIs were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples compared to the total samples (Tables 5-1 and 5-2). Detection frequencies by material type for copper, molybdenum, and uranium were also similar in the MWMP and solid/total samples.

Mercury and radium-228 were detected in approximately 5% and 3% of the MWMP samples, respectively, and in 64% and 100%, respectively, of the solid/total samples. Detection frequencies by material type for mercury were also similar in the MWMP and solid/total samples. The lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in OU-4b mercury is likely to be less mobile than the other COIs.

Selenium and radium-226 were detected in 74% and 47% of the MWMP samples, respectively. For comparison, they were detected in 96% and 100%, respectively, of the solid/total samples. The lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in the South WRA selenium and radium-226 are likely to be less mobile than the other COIs. Unlike other COIs, the detection frequencies for selenium and radium-226 varied among the different material types. In MWMP samples from alluvium, selenium was detected less frequently compared to waste rock and native

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soil samples. In MWMP samples from waste rock, radium-226 was detected more frequently compared to alluvium and native soil samples.

With respect to material types, there are inconsistent trends in terms of MWMP COI concentrations and detection frequencies. This suggests that material type may influence the leaching potential differently for different COIs, and that there is uncertainty in assigning relative mobility to COIs. Also, in the context of the MWMP results, COI mobility refers to the dissolved fraction.

As discussed above, MWMP results are a conservative estimate of the leaching potential of the sample material and potential effects on water quality should the material become saturated with surface runoff or groundwater. However, current conditions make such saturation rare or unlikely.

5.6.5 Acid Base Account Results

ABA analysis is a method to assist in predicting and assessing the acid generation and neutralization potential of waste rock. As described in Section 5.3.2, ABA samples were collected from select sample intervals at all borehole locations. ABA summary statistics are presented in Table 5-4. ABA consists of multiple analyses, including AGP, ANP, NPR, and NNP.

As described previously in Section 4.6.5, general criteria for predicting whether material is PAG or non-PAG material are shown below:

NPR:

- NPR < 1 = PAG
- NPR > 3 = Non-PAG in Nevada
- 1 ≤ NPR ≤ 3 = Uncertain

NNP:

- NNP < -20 = PAG
- NNP > 20 = Non-PAG
- -20 ≤ NNP ≤ 20 = Uncertain

Figure 5-29 shows charts of NPR by material type in the South WRA. All material types had the majority of samples classified as non-PAG. Less than 10% of alluvium and waste rock samples were classified as PAG, and no native soil samples were classified as PAG.

Figure 5-30 shows charts of NNP by material type in the South WRA. Similar to NPR, all material types had the majority of samples classified as non-PAG or were in the uncertain range. No samples were classified as PAG using the NNP.

Consistent with the approach described in Section 4.6.5, Figure 5-30 presents the results of the NAG-supplemented NNP classification along with the NNP results. Using the NAG as a supplement to the NNP suggests that the majority of all samples from all material types are likely non-PAG. In addition, the results are consistent with the classification from the NPR that suggest that no alluvium samples can be classified as PAG, and that less than 10% of waste rock samples can be classified as PAG.

When looking at the NPR, NNP, and NNP with NAG, using the NNP for PAG classification yields more uncertain results; however, all methods indicate that the majority of materials in the South WRA are non-PAG. As such, it is likely that South WRA materials will not generate acidic pH values and acidic conditions. As described in Section 5.7, the materials in the South WRA have very limited contact with significant

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amounts of surface runoff or groundwater, which in addition to the non-PAG material classification, would preclude acid generation from the waste rock.

5.7   Fate and Transport

This section discusses the fate and transport of COIs in waste rock and alluvium in the South WRA. Potential routes of migration are described in the following sections. Fate and transport of COIs in W-3 and S-23 are consistent with the fate and transport of COIs in the South WRA and are therefore not presented in this section. However, fate and transport of COIs in W-3 and S-23 are summarized in Section 5.8 as well as presented in their entirety in the OU-8 PA RI/FS (Wood, 2020a).

5.7.1   Geochemical Characteristics

COIs within the South WRA are inorganic chemicals. Except for radionuclide COIs, these inorganic chemicals do not transform or degrade into other chemicals that exhibit different toxicity or mobility.

5.7.2   Potential Transport Pathways and Mechanisms

As described in Section 5.2.2, the potential transport mechanisms identified for the South WRA consist of:

- Transport by water erosion/surface water runoff
- Leaching/percolation to subsurface soil
- Transport to groundwater
- Transport by wind erosion

Each of these potential transport pathways are discussed below.

5.7.2.1   Transport by Water Erosion/Surface Water Runoff

The low annual precipitation for ACMS results in few events capable of eroding and transporting COIs in the South WRA. Any transport that does occur would likely be from topographically high to low areas on the tops of the pile or from side slopes to the base of the pile. Because of the coarse-grained nature of the South WRA and the low percentage of fines observed during sampling (Section 5.3.2.1 and Appendix 5C), transport of COIs in runoff is anticipated to be limited. Significant water ponding has not been observed within the South WRA based on field observations and publicly available recent aerial photography.

Transport of COIs in surface runoff away from the South WRA can only occur by runoff on the side slopes of the piles. Field observations did not detect evidence of runoff mobilizing material away from the South WRA (Appendix 5H). These observations noted little to no rilling, erosion, base of slope deposition, or washout, which would be indicative of transport of waste rock and COIs in runoff.

As a result of the factors listed above, the water erosion/surface water runoff transport pathway away from the South WRA is incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives.

5.7.2.2   Leaching/Percolation to Subsurface Soil

Similar to transport by water erosion, because of the low annual precipitation and high annual evaporation rates, transport of COIs from the waste rock to the underlying soil is not expected to occur. A comparison of metals concentrations in mine-related material and the underlying native soil also suggests no significant leaching or percolation to subsurface soil. Four of the six COIs (copper, mercury, uranium, and radium-226) do not exceed their respective BCLs in any of the native soil samples collected beneath

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the South WRA. As described in Section 5.6.3.1, one molybdenum sample in native soil exceeded the BCL, however, this sample was vertically constrained by both shallow and deep samples that did not exceed the BCL. This suggests that either the molybdenum concentration is a naturally occurring outlier, or representative of limited impact to native soil that does not extend deeper beneath the South WRA. As described in Section 5.6.3.1, Selenium concentrations above the BCL are also present in native soil at two of the three deep boreholes. These concentrations are generally less than concentrations in the overlying alluvium and waste rock material. Similar to molybdenum, these selenium concentrations above the BCL may represent limited impact that could have occurred during the initial stages of mining operation when the thickness of the South WRA was much less than it is currently.

In addition to the low COI concentrations in native soil, the thicknesses of the South WRA is variable, but thicknesses observed during drilling range from 131.5 to 182 feet. During the OU-4a RI (CEC, 2019), an evaluation of the vadose zone details shows that because of an annual pan evaporation rate that is approximately 13 times higher than the annual precipitation rate, a strong net evaporative condition exists in the vadose zone. Additionally, the OU-4a RI suggests that the wetting front from even large winter precipitation events (e.g., January 2017) likely has limited impact in the subsurface. While the waste rock is generally coarser than the OU-4a soils, a similar highly evaporative process is expected in the South WRA. Because of this coarseness, the depth of infiltration in the South WRA is likely greater than that observed in OU-4a. However, the amount of precipitation that may move through the waste rock to subsurface soil would be limited, based on the thickness of the South WRA and the amount of evapotranspiration that occurs at ACMS.

Because of the thickness of the South WRA and given the annual climatic conditions, no discernible downward percolation of precipitation or impacts to subsurface soils are expected through the entire column of the South WRA. The impact of larger storm events would likely be similarly limited, given the physical setting of the waste rock and high evapotranspiration conditions at ACMS. Even though MWMP indicate that portions of the waste rock have the potential to leach metals, no mechanism exists for sufficient amounts of precipitation to reach the underlying soil to create these conditions. Additionally, the ABA results indicate that the majority of material in the South WRA is not likely to create acidic conditions, which also reduces the potential for metals leaching.

As a result of the factors listed above, the leaching/percolation transport pathway to subsurface soil beneath the South WRA is currently incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives.

5.7.2.3 Transport to Groundwater

Only a small portion of the shallow aquifer is present beneath the South WRA, and groundwater in bedrock is well below the base of the waste rock. Mobilization of COIs to groundwater beneath the South WRA also does not appear to be occurring. The OU-1 FRIR (CEC, 2020) does not consider or describe the South WRA as a past or current source of groundwater contamination. Even if COIs were present beneath the waste rock, transport through a large vadose zone would be unlikely (Section 5.4). As described in Section 5.7.2.2, evaporation exceeds average annual precipitation, and the wetting front from even large winter precipitation events likely has limited impact in the subsurface. As discussed in the OU-4a RI (CEC, 2019), and in Section 4.7.2.3, larger precipitation events are infrequent and that any impact beneath the South WRA due to a large precipitation event would also be infrequent and discontinuous, such that the impact would likely not be discernable in groundwater.

As discussed in Section 5.4, the majority of groundwater beneath the South WRA is in bedrock, rather than alluvium. Depending on the location, upwards of 120 feet of unsaturated bedrock can occur before groundwater is encountered as recorded in the borehole log for PLMW-3R (BC, 2014). The generally

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competent nature and low permeability of the bedrock, as compared to the overlying native soil, would further impede the progress of any wetting front from reaching the underlying groundwater.

Based on these multiple lines of evidence, the transport pathway to groundwater beneath the South WRA is incomplete and will be so in the future. In addition, groundwater flow beneath the South WRA is generally to the north towards the Pit Lake and therefore, does not flow northward beyond the pit and away from the ACMS. While there may be uncertainty in predicting future conditions, the transport pathway to groundwater will be incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives. Further evaluation of groundwater transport beneath ACMS is included in the OU-1 FRIR (CEC, 2020).

5.7.2.4   Transport by Wind Erosion

Wind-blown dust was monitored along ACMS perimeter from January 2005 through March 2008 (BC, 2005; BC, 2009c). Results from the monitoring program indicated that no additional air quality data were needed to perform a risk assessment on the inhalation pathway. This risk assessment was performed as described in the *Baseline Human Health Risk Assessment for the Inhalation Pathway* (BC and Foxfire Scientific, 2011). The risk assessment concluded that there is no unacceptable heath risk attributable to a dust inhalation pathway. Because air transport from Site facilities has been addressed on a Site-wide basis, it is not evaluated further in this report.

5.7.3   Updated Conceptual Site Model

Based on the information presented in Section 5.7.2, the preliminary CSM presented in Section 5.2 has been updated to include a summary of the routes of transport and the physical nature of the South WRA. The CSM is presented schematically in Figure 5-31. As stated in Section 5.7, the transport mechanisms and pathways in the South WRA are generally consistent with those in W-3 and S-23. This CSM does not include exposure pathways or receptors as those will be developed in the forthcoming risk assessment as described in Section 7.0.

The South WRA is comprised of approximately 90 million tons of alluvial material removed above the ore body and approximately 25 million tons of rock waste generated from removal of the cap rock above the ore (CH2M Hill, 2010). The variability of the source materials resulted in chemical variability in the waste piles, with both waste rock and alluvium showing differing concentrations of COIs. Overall, COI concentrations are lower or similar in the mine-related material in the South WRA compared to W-3 and S-23. However, when looking at the components of the mine-related material, waste rock from the South WRA show similar COI concentrations to the W-3 waste rock.

This CSM for the South WRA describes alluvium and waste rock being delivered to the South WRA and placed in a series of end dumps. Because of this mechanical deposition, and presented in the analytical results, the COIs do not show consistent trends laterally or with depth. Rather, the concentrations likely represent the variation in the material (waste rock or alluvium) that was being mined and transported to the South WRA as well as the particular area of the pile that the rock was placed at a given time. During mining, waste rock not containing appreciable amounts of copper was generally taken to the South WRA, low-grade ore was taken to W-3 and S-23, and higher-grade ore was taken to the process area. The exact nature of this segregation process is unknown and may have resulted in some waste rock being delivered to the South WRA that was chemically similar to the waste rock in W-3. Regardless of the process, because of this segregation prior to delivery, a consistent range of COI concentrations occurs within the South WRA. COI concentrations within the South WRA are within one to two orders of magnitude of one another. Additionally, as discussed further in Section 5.6.3, results from 2019-2020 and the 2010 Potential Cover Materials Evaluation are generally consistent with one another, suggesting that the observed

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ranges in concentrations from the two investigations represent the overall nature of the alluvium and waste rock.

The thickness of the South WRA material ranged from approximately 131.5 feet to 182 feet. The native soil contact beneath the South WRA generally slopes from west to east. There is a large vadose zone of approximately 120 to 200 feet beneath the bottom of the waste rock. As described in Section 5.3.2, only three borings (as specified in the approved Combined FSAP) were advanced into native soil beneath the South WRA. However, because of the thickness of the South WRA material and the underlying vadose zone, there is no exposure pathway to the native soil and groundwater beneath the South WRA, and therefore, the number of native samples to assess nature and extent is considered sufficient.

Transport of COIs away from the South WRA is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. Additionally, the thicknesses of the South WRA, the lack of acid-generating materials, the depth to the groundwater table, and the presence of bedrock beneath the South WRA inhibit the transport of COIs to groundwater.

5.8   Results Summary

Results from the South WRA RI are presented in this section. In addition, in order to have a comprehensive summary of the waste rock areas in OU-5, the relevant conclusions for W-3 and S-23 are also presented. Conclusions for W-3 and S-23 were originally presented in the OU-8 PA RI/FS.

5.8.1   South WRA

The main results for the South WRA are as follows:

- In 2018, samples were collected from five boreholes with depths ranging from approximately 27 to 110 feet bgs. In 2019-2020, samples were collected from 32 shallow and three deep boreholes. The shallow boreholes were each advanced to 15 feet bgs. The three deep boreholes were advanced through the South WRA and into native soil. In the three deep boreholes (WRSB-206, WRSB-207, and WRSB-208), the thickness of the South WRA materials were observed to be 182 feet, 135 feet, and 131.5 feet, respectively.

- Samples were submitted for laboratory analysis of metals and radionuclides at all locations and sample depth intervals. At select locations and depth intervals, samples were also submitted for laboratory analysis of MWMP extract and ABA/NAG.

- COIs were identified by evaluating the data against BCLs. Based on the comparison, copper, mercury, molybdenum, selenium, uranium, radium-226, and radium-228 were retained as COIs and evaluated in the RI.

- Several of the COIs (copper, molybdenum, selenium, uranium, and radium-226) showed a bimodal distribution, suggesting that two material types may be present in the South WRA. Based on the COI distribution and historical information for the South WRA, these material types were designated alluvium and waste rock. From this classification, approximately two thirds of the mine-related material samples are classified as alluvium and one third is classified as waste rock.

- Spatial geochemical variability is observed laterally in the South WRA. COI concentrations generally do not follow consistent trends throughout the South WRA, which likely is a result of the mechanical placement of the materials during mining operations.

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- The South WRA contains COI concentrations above their respective BCLs. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, and radium-228.

- Two-sample hypothesis testing was performed to assess COI differences between the different depth intervals in the upper 15 feet at locations WRSB-206 though WRSB-240. Based on the testing, the four depth intervals areas have statistically equivalent concentrations of all COIs, suggesting that there is limited variability by depth in the upper 15 feet of the South WRA.

- Concentrations of COIs also were detected in the MWMP extract with uranium and molybdenum being detected most often followed by copper, selenium, radium-226, mercury, and radium-228. Copper, molybdenum, and uranium were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples as compared to the total samples.

- When looking at the NPR, NNP, and NNP with NAG, all methods indicate that the majority of materials in the South WRA are non-PAG. As such, it is likely that South WRA materials will not generate acidic pH values and acidic conditions. As described in Section 5.7, the materials in the South WRA have very limited contact with significant amounts of surface runoff or groundwater, which in addition to the non-PAG material classification would preclude acid generation from the waste rock.

- The CSM for the South WRA describes alluvium and waste rock being delivered to the South WRA and placed in a series of end dumps. The mine-related materials have not been processed unlike the mine-related material in OU-4b and OU-6. Because of this mechanical deposition, lack of processing, and as presented in the analytical results, the COIs do not show consistent trends laterally or with depth. Rather, the concentrations likely represent the variation in the material (waste rock or alluvium) that was being mined and transported to the South WRA as well as the particular area of the pile that the rock was placed at a given time. During mining, waste rock not containing appreciable amounts of copper was taken to the South WRA, low-grade ore was taken to W-3 and S-23, higher grade ore was taken to the process area. Because of this segregation prior to delivery, a consistent range of COI concentrations occurs within the South WRA. COI concentrations within the South WRA are within one to two orders of magnitude of one another. Additionally, results from 2018 and 2019-2020 and the 2010 Potential Cover Materials Evaluation are generally consistent with one another, suggesting that the ranges in concentrations from the two investigations represent the overall nature of the alluvium and waste rock.

- Transport of COIs away from the South WRA is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. Additionally, the thicknesses of the South WRA, the lack of acid-generating materials, the depth to the groundwater table, and the presence of bedrock beneath the South WRA inhibit the transport of COIs to groundwater.

5.8.2   W-3 and S-23

The RI for W-3 and S-23 has been completed and is presented in the final OU-8 PA RI/FS (Wood, 2020a). Conclusions from that document are presented again here to create a comprehensive summary of all the waste rock areas in OU-5:

- Both S-23 and W-3 contain COI concentrations above their respective BCL. Of the COIs identified in the RI, mercury was most often detected above the BCL followed by copper, selenium, molybdenum, antimony, radium-226, and uranium.

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- Spatial geochemical variability is observed both laterally and with depth in W-3 and S-23. COI concentrations generally do not follow consistent trends throughout the waste rock piles, which likely is a result of the mechanical placement of the materials during mining operations.

- Two-sample hypothesis testing was performed to assess COI differences between S-23 and W-3. Based on the testing, S-23 overall contains higher concentrations of copper and selenium, and W-3 overall contains higher concentrations of radium-226. The two areas have statistically equivalent concentrations of antimony, mercury, molybdenum, and uranium.

- Concentrations of COIs also were detected in the MWMP extract with copper being detected most often followed by selenium, antimony, molybdenum, uranium, radium-226, and mercury. Copper was the only COI detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples as compared to the total samples.

- Upon review of the NPR and NNP analyses, using the NNP for PAG classification yields more uncertain results, making PAG classification using NPR a more conservative approach. For W-3, 32% of the samples had an NPR greater than three and would be classified as non-PAG. There were 30% of the samples that had an NPR less than one and would be classified as PAG; the remaining 38% of the samples fell in the uncertain range. For S-23, 6% of the samples had an NPR greater than three and would be classified as non-PAG. Lastly, 94% of the samples had an NPR less than one and would be classified as PAG. No samples from S-23 had an NPR falling in the uncertain range.

- In general, S-23 has a greater number of samples that can be classified as PAG. S-23 also has higher overall values of AGP and lower values of ANP. Pyritic sulfur, sulfate sulfur, and total sulfur were also detected more often and at overall higher concentrations in S-23 as compared to W-3.

- The CSM for W-3 and S-23 describes low-grade oxide and sulfide ore being delivered to the waste rock areas and placed in a series of end dumps. Because of this mechanical deposition, and as presented in the analytical results, the COIs in each pile do not show consistent trends laterally or with depth. Rather, the concentrations likely represent the variation in the material that was being mined and transported to the waste rock area as well as the particular area of the pile that the rock was placed at a given time. During mining, low-grade ore was taken to W-3 and S-23, higher grade ore was taken to the process area, and waste rock not containing appreciable amounts of copper was taken to the South WRA. Because of this segregation prior to delivery to W-3 and S-23, a consistent range of COI concentrations occurs within each of the individual piles. Concentrations within each pile are generally within one to two orders of magnitude of one another. Additionally, results from the 2018 PAI and the 2010 Potential Cover Materials Evaluation are generally consistent with one another, suggesting that the observed variability is representative of the nature of the waste rock.

- Surface transport of COIs away from W-3 and S-23 is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. Additionally, the thicknesses of the waste rock piles, the depth to the groundwater table, and the presence of bedrock beneath W-3 and S-23 inhibit the transport of COIs to groundwater.

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6.0   OU-6 – Oxide Tailings

The RI information for OU-6 is presented in this section. A summary and conclusion of the results is presented in Section 6.9, and in discussion with the other OUs in Section 8.0.

6.1   Summary of Previous Investigations and Assessments

Previous investigations and assessments conducted within and regarding OU-6 are described in the following sections. The investigations consist of the 2002 Investigation and 2009 Removal Action Characterization, the 2005 Process Area Soils Characterization, the 2009 Geotechnical Characterization, the 2010 Characterization of VLT using X-Ray Fluorescence and Laboratory Analysis, the 2010 Characterization of Potential Cover Materials, the 2018 Pre-Design Component Investigation, and the 2020 Material Screening Assessment. Relevant data from these previous investigations are provided in Appendix 6A except where discussed further below. Sample locations from these investigations are shown on Figure 6-1. The current extent of COIs at OU-6 includes the entire area delimited for this OU, based on the available data presented in this section. VLT in certain areas in OU-6 has been removed and used as cover in other areas of the ACMS (Section 6.3). As a result of these activities, the material at certain sampling locations has been removed subsequent to sampling activities. The locations are shown on Figure 6-1. Even though VLT at these locations is no longer in OU-6, the data from them was collected when the VLT was still in place in OU-6 and therefore are still utilized in this evaluation as they are representative of the VLT within the OU.

6.1.1   2002 Investigation and 2009 Removal Action Characterization

The 2009 *Anaconda Evaporation Ponds Removal Action Characterization Data Summary Report - Revision 1* (RAC DSR) (BC, 2009d), presented previously available VLT chemical data as part of an evaluation to use VLT as cover for portions of the evaporation ponds in OU-4a and Sub-Area A in OU-4b. These data were collected in 2002 by SRK Consulting on behalf of NDEP in support of a previous interim response action that used VLT materials to cover select areas of ACMS. Six primary samples and two duplicate samples were collected and analyzed for metals and Synthetic Precipitation Leaching Procedure metals. Limited information is available, including information on the quality of these data and, accordingly, the data from these eight samples are not evaluated in this document.

The RAC DSR summarized the 2002 data and stated that VLT materials to be used as fill for the interim cover over the evaporation ponds have the potential to leach metals. However, because of the subsurface characteristics beneath the areas to be covered (e.g., no cumulative flux of soil moisture towards groundwater) and the thickness of the proposed cover, the flux of meteoric water through the cover and the vadose zone was considered unlikely.

In addition to summarizing the 2002 data, the 2009 RAC included sampling of VLT that was already in place as a cover in the OU-4a evaporation ponds. Ten samples were collected at depths ranging from 0.5 to 2.5 feet bgs. Though the material sampled was VLT, it is material that was no longer in OU-6 at the time of sampling and therefore is not evaluated in this RI Report. The OU-4a RI (CEC, 2019) evaluates the evaporation ponds, including the existing VLT cover. The investigation was conducted under QAPP Version 5.0.

6.1.2   2005 Process Area Soils Characterization

BC collected 20 primary samples from eight locations (PA-PP1 through PA-PP4, PA-QQ1, PA-QQ2, PA-RR1, and PA-RR2, Figure 6-1) within OU-6 as reported in the *Data Summary Report for Process Area Soils Characterization* (BC, 2005). The samples were collected near former peripheral ore processing components and were collected to assess potential impacts to the soils in the vicinity of those

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components. The processing components investigated in OU-6 were the Acid Tanks (PA-PP locations), the Arimetco Crusher/Hopper (PA-QQ locations), and the Arimetco Stacker Area (PA-RR locations). All samples from these three areas were below the preliminary screening criteria (U.S. EPA industrial Preliminary Remediation Goals) for metals and radionuclides. Material information (i.e., VLT or other soil type) were not included in the report. Based on location and sampling photographs, the PA-PP locations are located entirely in VLT, and the PA-QQ and PA-RR locations are located in VLT at the surface. There is some uncertainty regarding the thickness of the VLT beneath the PA-QQ and PA-RR locations, which may affect COI results as discussed further in Section 6.6. The investigation was conducted under the 2003 version of the QAPP. Data from this investigation are provided in Appendix 6A.

6.1.3   2009 Geotechnical Characterization

Black Eagle Consulting (Black Eagle) performed sampling and materials testing in 2009 to support the BC RAC (BC, 2009d) to use VLT as a cover material. Samples were collected from 11 VLT test pits at depths ranging from 0 to 20 feet bgs and analyzed for geotechnical parameters. The report also included USCS material descriptions of the VLT, which ranged from clayey sand with gravel to poorly graded gravel with sand and clay. The report did not reference being conducted under a QAPP; however, the report was included and discussed in the *Implementation Work Plan - Revision 3, Anaconda Evaporation Pond Removal Action (Thumb Pond and Sub-Area A)* (BC, 2010a). Because of its presentation and previous use, it is assumed that the geotechnical data may be appropriate for use in future FS and RD/RA phases.

6.1.4   2010 Characterization of VLT using X-Ray Fluorescence and Laboratory Analysis

ARC performed an investigation using x-ray fluorescence (XRF) and laboratory analysis to further characterize the VLT as documented in the *Data Summary Report for the Characterization of Vat Leach Tailings Using X-Ray Fluorescence* (VLT XRF Characterization DSR) (ARC, 2010). The investigation was designed to:

1. further characterize the VLT materials beyond the limited data set presented in the 2009 report;

2. determine if statistically viable correlations exist between XRF measurements of metals concentrations obtained with a field portable XRF (FPXRF) instrument and laboratory analyses of metal concentrations using U.S. EPA Methods 6010B, 6020, and 7471A (FPXRF instruments do not measure for all the metals that can be analyzed in the laboratory, nor do they measure radionuclides such as uranium and thorium); and,

3. provide the basis, if any, to eliminate the use of "anomalous" VLT (i.e., VLT with metal concentrations above the to-be-determined threshold values) as interim cover materials. The investigation was conducted under QAPP Version 5.0.

Samples were collected from a total of 24 potential borrow area locations (VLT-XRF-1 through VLT-XRF-24, Figure 6-1). At each location, samples were generally collected from 0.5 to 1.0 feet bgs and from 2.5 to 3.0 feet bgs. The shallow sample interval was designated as "A" and the deeper interval was designated as "B." An additional "C" interval sample was collected from 1.75 to 2.25 feet bgs at one location to assess potential geochemical differences between VLT materials with red dust observed at that depth, and the gray-colored VLT materials observed in the shallow and deeper sample intervals at this and other locations. A total of 49 primary VLT samples were collected for characterization.

Following collection, the sample material was homogenized and split into two aliquots with one aliquot submitted for laboratory metals analysis, and the other retained for analysis using a FPXRF analyzer. This yielded FPXRF results and laboratory results for all 49 samples collected during the investigation. After

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laboratory and FPXRF analysis, the results were compared to assess the performance of the analyzer with respect to the laboratory results. Data evaluation and recommendations were not included in the data summary report for this investigation. However, it was noted in the transmittal letter for the investigation that based on the information presented in the VLT XRF Characterization DSR (ARC, 2010), ARC concluded that field screening during the evaporation ponds removal action would not be beneficial or useful for the upcoming removal action.

As stated above, the FPXRF data and laboratory data are presented in the original report. However, as described further in Section 6.5, only the laboratory data have been retained for data evaluation and presentation in this RI Report. It is important to note that even though the sample IDs from this investigation contain a VLT-XRF- prefix, the data presented in this report are laboratory data. Therefore, these sample IDs are used in figures and appendices in this report which present laboratory data. Because the FPXRF results are duplicative to the laboratory results, the FPXRF data are not necessary and are not presented nor evaluated in this RI Report, and will also not be used in the forthcoming HHRA and SLERA. Laboratory data from the investigation are provided in Appendix 6A.

6.1.5   2010 Characterization of Potential Cover Materials

ARC performed an investigation that collected data to support decisions regarding materials that may be used for interim covers and/or the design of final closure caps and to supplement pre-existing data (ARC, 2011). Samples were collected from multiple areas of the ACMS: native alluvium, South WRA, W-3, S-23, oxide tailings, sulfide tailings, and HLP materials. The investigation was conducted under QAPP Version 5.0.

VLT samples were collected at 10 locations in OU-6 (CM-VLT-01 though CM-VLT-10, Figure 6-1) to supplement data collected during the FPXRF investigation. The laboratory sample locations were collocated with previously collected sample locations from the FPXRF investigation (Section 6.1.4). During the FPXRF investigation, all samples were analyzed for total metals at an analytical laboratory in addition to being analyzed by a FPXRF scanner. Because total metals data already existed at the 10 collocated locations, none of the samples from the cover materials investigation were analyzed for total metals. Three of the 10 locations were sampled by backhoe and samples were submitted for laboratory analysis of plant growth parameters, radionuclides, MWMP metals and radionuclides, ABA/NAG, and geotechnical properties. The remaining locations were sampled by hand auger and were analyzed only for geochemical parameters (radionuclides, MWMP, and ABA/NAG).

Results from the VLT were evaluated for potential use as cover material relative to six categories: metals and radionuclides mean/maximum values, MWMP leachate concentrations less than drinking water MCLs, acid-generating potential, potential to support plant growth, plant-available moisture storage capacity, and saturated hydraulic conductivity. Relative to the other materials evaluated, the soil samples from the VLT were moderately favorable for acid-generation potential, and least favorable for all other categories. The investigation did not provide recommendations on which materials are suitable as a cover material. Data from this investigation are provided in Appendix 6A.

6.1.6   2013 Standing Rain Water Opportunistic Sampling

BC performed an opportunistic surface water collection event conducted in 2013. This event was described in detail in Appendix H of the OU-1 FRIR (CEC, 2020). In summary, there was a 1.55-inch rain event that occurred July 4, 2013. Following the rain event, standing water was observed at numerous locations areas across the ACMS where standing water historically had not been recorded or observed. On July 8, 2013, ARC requested (via e-mail) that the U.S. EPA approve the collection of standing rain water samples for water quality analysis, including tracer data for use in the OU-1 RI. After EPA approved this

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opportunistic sampling event on July 8, 2013, samples were collected from July 9 through July 11, 2013. Five to seven days had elapsed between the rainfall and the sampling. Figure 6-1 shows the one location (SRW-VLT-1) collected from OU-6. The sampling was conducted under QAPP Version 5.0. Data from this investigation are provided in Appendix 6A.

6.1.7   2018 Pre-Design Component Investigation

The *Remedial Design/Remedial Action Work Plan for ROD 1 Closure Management Units* (RD/RA Work Plan) (Wood, 2018), included a PDCI which described data collection activities to support RD/RA activities. In conjunction with the PDCI and in discussion with the NDEP, an additional scope of work for the VLT across OU-6 and the South WRA in OU-5 was developed. The objective of sample collection in the VLT and South WRA was to collect soil geochemical and agronomic data in support of the RD/RA cover materials evaluation. In the VLT, additional geochemical data were needed throughout the tailings.

The scope of the investigation in the VLT consisted of advancing 12 boreholes (VLTSB-01 though VLTSB-12, Figure 6-1) to approximately 25 feet bgs and collecting three composite samples for laboratory analysis from each borehole. All samples collected during the investigation were analyzed for radionuclides, and select samples were analyzed for ABA/NAG, MWMP metals, and general chemistry parameters. All VLT materials observed during drilling were described as poorly graded sands and gravels similar to the clayey sands with gravel and the poorly graded gravels described in the geotechnical investigation presented in Section 6.1.3. These materials were consistent throughout the OU and contained relatively high amounts of gravel and sand (approximately 90% to 95%) and low amounts of fines (approximately 5% to 10%).

The results from this scope of work were originally presented in the VLT and South WRA memo (Wood, 2020b), which was included as Appendix C to the MSA (Ramboll and Arcadis, 2020), which in turn was included as Appendix J to the *ROD 1 Arimetco Facilities (OU 8) Remedy, Regrade/Cap of Heap Leach Pads and Select Peripheral Areas, Design Summary* (Wood, 2020c). For reference, the MSA, including the VLT and South WRA memo, are presented as Appendix 5B. The MSA is described in further detail in the next section. Data from this investigation are provided in Appendix 6A. To be consistent with the recent investigations in OU-4b and OU-5, a database output for these data is provided in Appendix 6B.

6.1.8   2020 Material Screening Assessment

As previously described, the MSA was prepared as an appendix to support RD/RA activities in OU-8. The purpose of the assessment was to document screening results intended to support selection of cover materials that may be placed on the heap leach pads and other areas to achieve post-closure performance standards (Ramboll and Arcadis, 2020). The MSA evaluated available VLT data, and prepared risk evaluations for South WRA and VLT, which included both human health and ecological risk-based screening components.

For the VLT, the MSA concluded that from a human health perspective, the use of VLT as a cover material is considered acceptable under current/future industrial land uses within the former mine property. From an ecological perspective, exposure to VLT is not expected to pose an elevated risk of adverse effects (Ramboll and Arcadis, 2020).

6.2   Preliminary Conceptual Site Model

Information relating to a CSM for OU-6 has been presented previously in the Site-wide CSM (BC, 2009a). To provide context for the potential transport pathways in the Site-wide CSM, a physical setting for OU-6 is presented in the following sections.

6.2.1   Physical Setting

As described in Section 2.2.3, the VLT in OU-6 has an average height exceeding 100 feet and an estimated maximum thickness of approximately 190 feet (Figure 6-2). The top surfaces are composed of multiple benches and VLT mounds. Using the GMS software package, the estimated volume of VLT remaining in OU-6 is approximately 49 million cubic yards.

VLT is composed of crushed rock at the base of the leach vats that remained following the extraction of copper from the oxide ore. The oxide ore came from the upper zone of the Yerington orebody, where the most predominant copper mineral, chrysocolla, is located (CH2MHill, 2010). Following the extraction of copper, the VLT was removed from the leach vats and transported to the tailings area by haul trucks.

The VLT is a potential source of metals and/or radionuclides. Primary release mechanisms are in the form of solid particles released as wind- blown dust and fine-grained transport with storm water runoff.

6.2.2   Potential Transport Pathways

This section addresses the potential transport pathways through which COIs could be dispersed in the environment. The Site-wide CSM included a general discussion of transport mechanisms for the VLT (BC, 2009a). In conjunction with the primary release mechanisms described in Section 6.2.1, the transport pathways evaluated for the VLT in OU-6 consist of:

- Transport by water erosion/surface water runoff
- Leaching/percolation to subsurface soil
- Transport to groundwater
- Transport by wind erosion

Each of these potential transport pathways are discussed further in Section 6.7.

6.3   Use of VLT at ACMS

VLT has been used on Site as cover and construction material in multiple OUs, as follows:

- Sulfide Tailings (OU-4b) – VLT was used in the construction of the sulfide tailings embankments described in Section 2.2.1. Also described in Section 2.1.1, when mining operations ceased in 1978, approximately 95% of the surface of the sulfide tailings was covered with VLT. As part of a
- removal action conducted in 2006 to address dust concerns, U.S. EPA covered most of the remaining exposed sulfide tailings with VLT (CH2M Hill, 2010). A discussion of VLT thicknesses in the sulfide tailings is also presented in Section 4.4.
- Sub-Area A (OU-4b) – This portion of the sulfide tailings was covered with VLT by ARC in 2010 to mitigate standing water and the generation of fugitive dust. The cover was approximately 18 to 36 inches thick (BC, 2011a).
- Lined and Unlined Evaporation Ponds (OU-4a) – The lined evaporation ponds were constructed with a 1 to 2.5 feet thick VLT base below the liner. Pond berms and access roads on the lined evaporation ponds were also constructed with VLT. The unlined evaporation pond was constructed with VLT berms but no VLT was used as a pond base (BC, 2009d).
- Thumb Pond (OU-4a) – The thumb pond was covered with VLT by NDEP in 2003 and again in 2010 by ARC to mitigate standing water and the generation of fugitive dust. The 2003 cover was approximately 8 to 12 inches thick and the 2010 cover, which overlaid the 2003 cover, was approximately 12 inches thick (BC, 2011a).

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- Calcine Ditch (OU-4a) – Other than when portions of the Calcine Ditch were covered with VLT by NDEP in 2001 (CH2M Hill, 2010), additional details on covering are not well documented. VLT currently covers the majority of the Calcine ditch in varying thicknesses. During a 2018 borehole investigation, VLT was encountered at thicknesses of up to approximately 20 feet (CEC, 2019).

- Heap Leach Pads (OU-8) – VLT was used as the base for the Phase I/II, Phase III 4X, Phase III South, and Phase IV Slot HLPs, at thicknesses ranging from 2 to 10 feet. Additionally, VLT was used as part of the leached material in the Phase III 4X and Phase III South HLPs, and was the primary material leached in the Phase IV VLT HLP (CH2M Hill, 2010).

- Process Area (OU-3) – When ore processing began, the ground surface of the process area was composed of native soil. Since that time, VLT has been used as a road base and cover to limit the occurrence of fugitive dust. VLT usage was sporadic and varies in thickness from 0 to greater than 10 feet (BC, 2005).

Figure 6-3 summarizes the VLT usage across ACMS. While VLT has been used across the ACMS, the evaluation in the document is focused on the VLT still remaining in OU-6. VLT in other OUs has been characterized by the RIs for the respective OUs in which the VLT was located.

6.4   Hydrogeology

In OU-6, 2019 shallow aquifer groundwater levels in the vicinity of the tailings (B/W-73S, B/W-74S, HLP-08S, PA-MW-2S, PA-MW-4S) ranged from 78.32 to 171.23 feet bgs (4,333.51 to 4,336.51 feet amsl). Locations of monitoring wells in the vicinity of OU-6 are shown on Figure 6-1. Shallow groundwater in OU-6 generally flows toward the north. The majority of OU-6 is underlain by the Shallow Zone, except on the western portion of the OU where groundwater is present in bedrock. The 2019 groundwater levels in bedrock monitoring wells in this portion (B/W-73S, HLP-5B, and HLP-6B) range from 165.54 to 182.97 feet bgs (4,375.72 to 4,338.58 feet amsl). These groundwater elevations correspond to a vadose zone of approximately 40 to 130 feet beneath the bottom of the VLT.

6.5   Data Quality Assessment

Unlike the 2019-2020 data presented for OU-4b and OU-5, sufficient previous data had been collected to support development of an RI for OU-6, as described in the Combined FSAP (Wood, 2019). Because of this, data evaluated in this OU-6 RI have already been reported in previous documents as presented in Section 6.1 and summarized in Tables 6-1 through Table 6-5, including summaries and/or assessments of data quality. All OU-6 data used in this RI are supported by U.S. EPA approved Site work plans and/or QAPP documents, rigorous sampling and analysis procedures, QA/QC protocols, and documentation requirements. Thus, the data are considered useable for quantitative analysis and decision-making purposes. A summary of the data collected during the various investigations as well as an assessment of data quality, are described in the following text.

RI data were collected to satisfy the DQOs and general objectives for the investigations performed in OU-6. DQOs and objectives are presented in the *Final Process Area (Operable Unit 3) Work Plan* (CH2M Hill, 2012), the *Revised VLT Characterization Work Plan Using X-Ray Fluorescence* (ARC, 2009), and the *Cover Materials Characterization Work Plan, Revision 2* (Cover Materials Work Plan) (BC, 2010b). Data collected in support of the OU-6 RI consist of the following:

- 2005 VLT data collected as part of the Process Area Soils Characterization of OU-3 (Section 6.1.2).

- 2010 VLT data collected as part of the Characterization of VLT using XRF (only laboratory data from the characterization is being used in this document as described in Section 6.1.4) and the Characterization of Potential Cover Materials (Section 6.1.5).

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- 2013 Standing rain water opportunistic sampling (Section 6.1.6)

- 2018 VLT data collected as part of the PDCI (Section 6.1.7).

Data quality for the 2005 VLT data (Section 6.1.2) was originally presented in the *Data Summary Report for Process Areas Soils Characterization* (BC, 2005). In general, the results from the VLT samples were found to be usable and of an acceptable quality. However, all antimony results from the investigation were rejected because of low matrix spike recoveries and antimony detections in blanks. Thus, antimony results from the 2005 investigation were not used or reported in this OU-6 RI.

For the 2010 VLT XRF characterization data (Section 6.1.4), the VLT XRF Characterization DSR (ARC, 2010) did not indicate any limitations to the data with regards to data quality. Furthermore, the Cover Materials Work Plan (BC, 2010b) indicated that the VLT XRF characterization data will support the RI/FS for OU-6. However, all FPXRF data were collected at locations where samples were collected for analysis at a fixed-based analytical laboratory. The duplicative sampling of XRF and analytical samples was conducted to assess the use of an FPXRF analyzer for field screening purposes. In addition, because the laboratory data include additional analytes and a level of accuracy not available from the FPXRF instrument, the FPXRF data represent a less robust dataset than the corresponding laboratory data. Because of these factors, and as stated in Section 6.1.4, only the laboratory data generated during the VLT XRF characterization effort are used in the RI. FPXRF data are not used in this RI and will not be used in the future HHRA and SLERA.

Data quality for the 2010 cover materials data (Section 6.1.5) were originally presented in the Cover Materials DSR (ARC, 2011). In general, sample results met the DQOs and all data are considered usable.

Because of the opportunistic nature of the 2013 standing rain water sampling (Section 6.1.6), no work plan or DQOs exist for the investigation. However, the sampling was approved by the U.S. EPA as described in Section 6.1.6, and the sample collection procedures followed QAPP requirements.

Data quality for the 2018 PDCI data (Section 6.1.7) was originally presented in the VLT and South WRA technical memorandum (Wood, 2020b). In general, the data were deemed available for use as quantitative data.

In summary, all laboratory data evaluated in the RI met the QAPP requirements, DQOs and general objectives, and were considered usable for this RI. The majority of the OU-6 COIs evaluated in the RI did not follow a normal distribution, therefore, non-parametric tests were used in statistical testing. For results reported as non-detect, statistical and spatial analyses used (or presented) the non-detect value in calculations and in graphical presentation of the data.

6.6   Nature and Extent of Contamination

This section presents the nature and extent of contamination for OU-6 Oxide Tailings, utilizing the data collected during the 2005 Process Area Soils Characterization (BC, 2005), 2010 XRF Characterization (ARC, 2010), 2010 cover materials evaluation (ARC, 2011) and the 2018 PDCI VLT data (Wood, 2020b). A summary of the relevant conclusions from OU-6 are presented in this document in Section 6.9 and Section 8.0.

6.6.1   Constituents of Interest

Although all data are presented in this RI (Appendix 6A), a subset of the analytes (i.e., COIs) is used to focus the discussion of nature and extent and fate and transport of contaminants. As previously discussed, COIs were selected to allow for a concise discussion of the general trends seen in the data. The selection of this subset is not intended to replace the screening process in the future HHRA and SLERA. Screening

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and evaluation of all analytes will be addressed in the future HHRA and SLERA, which will result in the identification of COPCs and COPECs.

The OU-6 data were evaluated against BCLs. In this RI, the soil COIs are compared to BCLs as developed in the Background Soils DSR (BC, 2009b). As proposed in the Background Soils DSR, Sub-Area A-1 BCLs are considered the most applicable BCL to OU-6.

The COIs identified and evaluated were based on elevated concentrations of analytes that were above the respective BCLs following these criteria:

- Analytes detected above their respective BCL in more than 10% of the sample population were retained as COIs. The cutoff value of 10% was chosen after reviewing the data and using professional judgement so that the evaluation could be focused on those analytes that more regularly exceeded their respective BCL.

- Analytes detected above their respective BCL in less than 10% of the sample population were not retained as COIs

- Analytes that were not detected in any sample above the laboratory reporting limit were not retained as COIs

- Analytes with no BCL (lithium, phosphorus, strontium, tin, and titanium) were not retained as COIs

Following these criteria, the soil analytes identified as COIs and evaluated in the RI consist of:

- Metals: antimony, total chromium, copper, magnesium, mercury, molybdenum, and selenium

- Radionuclides: radium-226 and radium-228 (radium-228 did not meet the criteria of being detected in more than 10% of the sample population, but is retained as a COI at NDEP request)

The COIs identified in this section are the focus of the nature and extent of contamination and fate and transport evaluations in this section and in Section 6.7. The discussions of these COIs are supported by map view figures and graphs referenced throughout the following sections.

6.6.2   OU-6 Material Types

Unlike other OUs, OU-6 is comprised entirely of VLT. Because of the controlled processes used to create the VLT, there is inherent chemical homogeneity in the material. Chemical homogeneity was observed through several evaluations, as described further in this section.

Two-sample hypothesis testing was performed using ProUCL Version 5.1 (U.S. EPA, 2015) to assess COI differences between the shallow and deep depth intervals. For antimony, total chromium, copper, magnesium, mercury, molybdenum, and selenium, shallow sample intervals were those collected from the ground surface to 2.5 feet bgs, and the deep intervals were those collected deeper than 2.5 feet bgs. Because of the sampling intervals selected during the collection of radionuclides (Section 6.1.5 and 6.1.7) for radium-226 and radium-228, shallow sample intervals were those collected from the surface to 6 feet bgs, and the deep intervals were those collected below 6 feet bgs. Based on the testing, the shallow and deep intervals areas have statistically equivalent concentrations of all COIs except radium-228, suggesting that there is limited variability by depth in the upper 25 feet of the VLT. Figures 6-4 through 6-8 show box plots comparing the two depth intervals, and the results of the statistical testing are shown on Table 6-6. ProUCL software output data are presented in Appendix 6C.

VLT COI concentrations in OU-6 were also compared to the VLT that had been placed as a cover in OU-4b, described in Section 4.6.2. Figures 6-9 through 6-13 show box plots comparing the two groups of VLT. In general, concentrations of most COIs between the two groups are similar. When looking at the IQR

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and CV, some variability is present in COI concentrations. However, the majority of IQRs and CVs of the OU-6 VLT COIs are generally lower or similar to the IQRs and CVs of the OU-4b COIs (Table 6-7). As discussed in Section 4.6.2, while the CV is relative to the mean rather than the median, it can still be used along with the IQR as a supporting evaluation, while recognizing there may be some uncertainty in its use. The similarity between the two groups of VLT further suggests that the variability is limited in the VLT.

Because of the consistent physical and chemical properties, the VLT are treated as a single material group in the remainder of the nature and extent section.

6.6.3 Metals and Radionuclide Results

Table 6-2 summarizes soil metal and radionuclide statistics for COIs from the OU-6 analytical results. The tables provide: 1) the number of observations, detections, detection frequency, minimum, maximum, mean, median, and the CV of all analyzed metals and radionuclides; 2) corresponding Sub-Area A-1 BCLs as described in Section 6.6.1; and 3) percent of observations that exceed these BCLs. A summary of COIs for OU-6 are described in more detail below.

Some spatial geochemical variability is observed laterally in OU-6; however,

- Total chromium, magnesium, radium-226, and radium-228 concentrations are within the same or one order of magnitude.

- Antimony, mercury, and selenium concentrations are within two orders of magnitude.

- Copper and molybdenum concentrations show higher variability but are within three orders of magnitude of one another.

Of the COIs, radium-226 was most often detected above the BCL followed by copper, mercury, selenium, molybdenum, total chromium, antimony, magnesium, and radium-228.

In general, COI concentrations are lower in the northwestern portion of the OU, in the vicinity of the PA-QQ and PA-RR sample locations (Figure 6-1). This is the area of the Arimetco Crusher/Hopper and Stacker Area. This area is on the northern margin of the VLT and much of the material in the area may have been excavated and placed in the nearby OU-8 HLP (BC, 2005), leaving a limited amount of VLT at the surface at the time of sampling. As described in Section 6.1.1, limited information on material type exists for samples in these locations but it is possible that some of the deeper sample intervals could be a mixture of VLT and underlying material that was mixed during past excavation activities.

6.6.3.1 Individual COI Results

The soil COI geochemical trends are plotted on maps using a consistent color-coding scheme. Concentrations at or below the applicable BCL are shown in green. Concentrations between the BCL and 10 times the BCL are shown in yellow. Concentrations between 10 times the BCL and 100 times the BCL are shown in orange. The intent of the color-coding scheme is to help the reader visualize spatial variations in the COI concentrations.

Complete COI results as well as the results for other metals and radionuclides not identified as COIs are presented in Appendix 6A. Discussion of the spatial distribution of each COI is provided below.

Antimony: The distribution of antimony is shown on Figure 6-14, and summarized as follows:

- Antimony concentrations ranged from 0.81 to 12 mg/kg. The maximum antimony concentration was detected at location VLT-XRF-24 at a depth of 0.5 to 1 feet bgs.

Antimony concentrations are slightly variable across OU-6, with the highest concentrations in the southern area, and lower concentrations in the northern area (Figure 6-14).

Chromium: The distribution of total chromium is shown on Figure 6-15, and summarized as follows:

- Total Chromium concentrations ranged from 1.4 to 40 mg/kg. The maximum chromium concentration was detected at location VLT-XRF-23 at a depth of 0.5 to 1 feet bgs.

Chromium concentrations are generally consistent across OU-6, with the exception of an area in the northwest (described in Section 6.6.3) which has lower concentrations (Figure 6-15).

Copper: The distribution of copper is shown on Figure 6-16, and summarized as follows:

- Copper concentrations ranged from 5.0 to 3,100 mg/kg. The maximum copper concentration was detected at location PA-PP3 at a depth of 0.5 to 1 feet bgs.

Copper concentrations are generally consistent across OU-6, except for an area in the northwest (described in Section 6.6.3) which has lower concentrations (Figure 6-16).

Magnesium: The distribution of magnesium is shown on Figures 6-17, and summarized as follows:

- Magnesium concentrations ranged from 1,600 to 12,000 mg/kg. The maximum magnesium concentration was detected at location VLT-XRF-19 at depths of 0.5 to 1 feet bgs and 2.5 to 3 feet bgs, respectively.

Magnesium concentrations are generally consistent across OU-6, with similar degrees of variability in the northern and southern portions of the OU, except for an area with somewhat higher concentrations in the middle of the northern area (Figure 6-17).

Mercury: The distribution of mercury is shown on Figures 6-18, and summarized as follows:

- Mercury concentrations ranged from 0.0010 to 0.93 mg/kg. The maximum mercury concentration was detected at location VLT-XRF-22 at a depth of 0.5 to 1 feet bgs.

Mercury concentrations are slightly variable, with the highest concentrations in the southern area, and lower concentrations in the area in the northwest (described in Section 6.6.3; Figure 6-18).

Molybdenum: The distribution of molybdenum is shown on Figure 6-19, and summarized as follows:

- Molybdenum concentrations ranged from 0.054 to 11 mg/kg. The maximum molybdenum concentration was detected at location PA-PP2 at a depth of 4.5 to 5 feet bgs.

Molybdenum concentrations are generally consistent across OU-6, except for an area in the northwest (described in Section 6.6.3) which has lower concentrations as seen on Figure 6-19.

Selenium: The distribution of selenium is shown on Figure 6-20, and summarized as follows:

- Selenium concentrations ranged from 0.19 to 13 mg/kg. The maximum selenium concentration was detected at location PA-PP2 at a depth of 4.5 to 5 feet bgs.

Selenium concentrations are generally consistent across OU-6, except for an area in the northwest (described in Section 6.6.3) which has lower concentrations (Figure 6-20).

Radium-226: The distribution of radium-226 is shown on Figure 6-21, and summarized as follows:

- Radium-226 concentrations ranged from 1.42 to 8.76 pCi/g. The maximum radium-226 concentration was detected at location VLTSB-06 at a depth of 10 to 15 feet bgs.

Radium-226 concentrations are generally consistent across OU-6, with similar degrees of variability in the northern and southern portions of the OU (Figure 6-21).

Radium-228: The distribution of radium-228 is shown on Figure 6-22, and summarized as follows:

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- Radium-228 concentrations ranged from 0.61 to 2.3 pCi/g. The maximum radium-228 concentration was detected at location PA-PP4 at a depth of 0.5 to 1 feet bgs

Radium-228 concentrations are generally consistent across OU-6, with similar degrees of variability in the northern and southern portions of the OU (Figure 6-22).

6.6.4 MWMP and Standing Rain Water Results

MWMP results from the 2019-2020 investigation and the 2013 standing rain water results are discussed in this section.

6.6.4.1 MWMP Results

As previously discussed in Section 4.6.4.1, the MWMP method is generally used for simulating leaching in a surficial or near-surface waste rock environment and has less of a direct application for the subsurface soil environment. The results provide a general estimate of the relative mobility of COIs from OU-6 materials, and will be utilized in the forthcoming SLERA. Estimates made using MWMP should be considered conservatively elevated because current conditions make saturation of subsurface materials rare or unlikely.

Summary statistics for MWMP metals and radionuclides results are presented in Table 6-3 and MWMP general chemistry results are presented in Table 6-4. As described in Section 6.1.5 and Section 6.1.7 MWMP samples were collected from select depth intervals from sampling locations and boreholes in OU-6. Concentrations of COIs were detected in the MWMP extract with copper and magnesium being detected most often followed by selenium, mercury, chromium, antimony, radium-226, molybdenum, and radium-228. MWMP results are presented in Appendix 6A, and a summary of these results for the COIs identified previously is provided in the following text.

- **Antimony:** MWMP antimony concentrations ranged from 0.00062 mg/L to 0.0044 mg/L, with a median concentration of 0.0013 mg/L. MWMP antimony was detected in 68% of MWMP samples.

- **Chromium:** MWMP chromium concentrations ranged from 0.0007 mg/L to 0.015 mg/L, with a median concentration of 0.0016 mg/L. MWMP chromium was detected in 73% of MWMP samples.

- **Copper:** MWMP copper concentrations ranged from 93 mg/L to 480 mg/L, with a median concentration of 275 mg/L. MWMP copper was detected in 100% of MWMP samples.

- **Magnesium:** MWMP magnesium concentrations ranged from 82 mg/L to 270 mg/L, with a median concentration of 160 mg/L. MWMP magnesium was detected in 100% of MWMP samples.

- **Mercury:** MWMP mercury concentrations ranged from not detected (less than 0.0001 mg/L) to 0.013 mg/L, with a median concentration of 0.00042 mg/L. MWMP mercury was detected in 86% of MWMP samples.

- **Molybdenum:** MWMP molybdenum concentrations ranged from not detected (less than 0.0002 mg/L) to 0.0048 mg/L, with a median concentration of 0.0021 mg/L. MWMP molybdenum was detected in 36% of MWMP samples.

- **Selenium:** MWMP selenium concentrations ranged from 0.0034 mg/L to 0.08 mg/L, with a median concentration of 0.014 mg/L. MWMP selenium was detected in 95% of MWMP samples.

- **Radium-226:** MWMP radium-226 concentrations ranged from not detected (less than 0.392 pCi/L) to 1.66 pCi/L, with a median concentration of 0.663 pCi/L. Radium-226 was detected in 58% of MWMP samples.

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- **Radium-**228**:** MWMP radium-228 concentrations ranged from not detected (less than 0.939 pCi/L) to 2.35 pCi/L, with a median concentration of 1.79 pCi/L. Radium-228 was detected in 17% of MWMP samples.

- **pH:** MWMP pH values ranged from 3.9 to 4.3 pH units, with a median value of 4.1 pH units.

Antimony, copper, magnesium, mercury, and selenium were detected in a similar percentage of samples in both MWMP samples and the total samples. The remaining COIs (chromium, molybdenum, radium-226, and radium-228) were detected less often in the MWMP samples compared to the total samples (Tables 6-2 and 6-3).

For chromium, molybdenum, radium-226, and radium-228, the lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in OU-6 these COIs are likely to be less mobile than the other COIs. Within the context of the MWMP results, COI mobility refers to the dissolved fraction.

As discussed previously, MWMP results are a conservative estimate of the leaching potential of the sample material and potential effects on water quality should the material become saturated with surface runoff or groundwater, though current conditions make such saturation rare or unlikely.

6.6.4.2   Standing Rain Water Results

Surface water is not typically present within OU-6. As discussed in Section 6.1.6, one surface water sampling event was conducted during periods when standing water was ephemerally present. From this event, one standing rain water sample, SRW-VLT-1, was collected from OU-6.

The standing rain water sample was collected on July 9, 2013, five days after the rain event. The total dissolved solids concentration from the sample was 1,200 mg/L, and the measured pH value was 4.91. COI concentrations from the one sample consisted of:

- Antimony – not detected (less than 0.0003 mg/L)

- Chromium - not detected (less than 0.0009 mg/L)

- Copper – 130 mg/L

- Iron – not detected (less than 0.2 mg/L)

- Magnesium – 58 mg/L

- Mercury – not detected (less than 0.0001 mg/L)

- Molybdenum – not detected (less than 0.0002 mg/L)

- Selenium – 0.0083 mg/L

- Radium-226 – not detected (less than 0.392 pCi/L)

Because of the ephemeral nature of standing rain water, the rarity of large rain events that would produce standing rain water, and the limited number of samples, standing rain water is not considered a significant media in describing the nature and extent of COIs in OU-6. However, the data may be utilized in the forthcoming HHRA or SLERA.

6.6.5   Acid Base Account Results

ABA analysis is a method to assist in predicting and assessing the acid generation and neutralization potential of waste rock. As described in Section 6.1.7, ABA samples were collected from select sample intervals at all 2018 borehole locations. ABA summary statistics are presented in Table 6-5. ABA consists of multiple analyses, AGP, ANP, NPR, and NNP.

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As described previously in Section 4.6.5, general criteria for predicting whether material is PAG or non-PAG material are shown below:

NPR:

- NPR < 1 = PAG
- NPR > 3 = Non-PAG in Nevada
- 1 ≤ NPR ≤ 3 = Uncertain

NNP:

- NNP < -20 = PAG
- NNP > 20 = Non-PAG
- -20 ≤ NNP ≤ 20 = Uncertain

Figure 6-23 shows the chart of NPR for the VLT in OU-6. Similar to the VLT in OU-4b, the majority of VLT samples fell in the uncertain and non-PAG range (12% and 48%, respectively). Approximately 40% of samples were classified as PAG however, which is a greater percentage than that seen in the VLT from OU-4b (Figure 4-44).

Figure 6-23 also shows the chart of NNP for the VLT in OU-6. The majority of NNP values fell in the uncertain rage and 5% were classified as non-PAG. The VLT in OU-4b (Figure 4-45) showed similar classifications, with all NNP values falling in the uncertain range.

When looking at the NPR and NNP, using the NNP for PAG classification yields more uncertain results, making PAG classification using NPR a more conservative approach. Materials classified as PAG have the potential to generate acidic pH values; however, it does not assure that acidic conditions will be realized. As described further in Section 6.7, the materials in OU-6 have very limited contact with significant amounts of surface runoff or groundwater, which would limit the amount of or preclude acid generation from the VLT.

Similar to the VLT in OU-4b, generally, the majority of VLT samples in OU-6 are either non-PAG or in the uncertain range.

6.7   Fate and Transport

This section primarily discusses the fate and transport of COIs in OU-6. Potential routes of migration are described in the following sections.

6.7.1   Geochemical Characteristics

COIs within OU-6 are inorganic chemicals. Except for radionuclide COIs, these inorganic chemicals do not transform or degrade into other chemicals that exhibit different toxicity or mobility. However, the inorganic COIs may change valence or bind to other elements or compounds, which could affect mobility.

6.7.2   Transport Pathways and Mechanisms

As described in Section 6.2.2, the transport mechanisms evaluated for OU-4b consist of:

- Transport by water erosion/surface water runoff
- Leaching/percolation to subsurface soil
- Transport to groundwater

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- Transport by wind erosion

Each of these conceptual transport pathways are discussed below.

6.7.2.1 Transport by Water Erosion/Surface Water Runoff

The low annual precipitation for ACMS results in few events capable of eroding and transporting COIs in OU-6. Potential transport that does occur would likely be from the top of the tailings pile to the base of the pile. VLT generally is a competent material and contains a low percentage of fines, as observed during sampling (Section 6.1.7). Because of these physical characteristics, transport of COIs in runoff away from OU-6 is anticipated to be limited. Transport from OU-6 is also constrained by the presence of the OU-8 HLPs (northeast and south). Outside of these constrained areas, field observations detected no evidence of runoff mobilizing material away from OU-6 (Appendix 6D). These observations noted the presence of rilling, and erosion on slope faces. However, the observations note little to no base of slope deposition or washout, which would be indicative of transport of VLT away from the piles in runoff.

As a result of the factors listed previously, the water erosion/surface water runoff transport pathway away from OU-6 is incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives.

6.7.2.2 Leaching/Percolation to Subsurface Soil

The low annual precipitation and high annual evaporation rates currently make transport of COIs from the VLT to the underlying soil unlikely. The thicknesses of the VLT are variable, with an average height exceeding 100 feet and an estimated maximum thickness of approximately 190 feet. During the OU-4a RI (CEC, 2019), an evaluation of the vadose zone details shows that, because of an annual pan evaporation rate that is approximately 13 times higher than the annual precipitation rate, a strong net evaporative condition exists in the vadose zone. Additionally, the OU-4a RI suggests that the wetting front from even large winter precipitation events (e.g., January 2017) likely has limited impact in the subsurface. VLT may be generally coarser than the OU-4a soils, and as result the depth of infiltration in the VLT is likely greater than that observed in OU-4a. However, the amount of precipitation that may move through the VLT to subsurface soil would be limited, based on the thickness of the VLT and the amount of evapotranspiration that occurs at ACMS.

Because of the thickness of the VLT and given the annual climatic conditions, no discernible downward percolation of precipitation or impacts to subsurface soils are expected through the entire column of the VLT. As shown on Figure 6-2, the majority of the VLT is greater than 25 feet thick and given the annual climatic conditions, it is unlikely that the thinner areas of VLT (less than 25 feet thick) present a significant area where percolation to the subsurface soil could occur. The impact of larger storm events would likely be similarly limited, given the physical setting of the waste rock and high evapotranspiration conditions at ACMS. Even though MWMP and ABA results indicate that portions of the VLT have the potential to leach metals and create acidic conditions, no mechanism exists for sufficient amounts of precipitation to reach the underlying soil to create these conditions.

As a result of the factors listed above, the leaching/percolation transport pathway to subsurface soil beneath OU-6 is incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives.

6.7.2.3 Transport to Groundwater

Mobilization of COIs to groundwater beneath OU-6 also does not appear to be occurring. The OU-1 FRIR (CEC, 2020) does not consider OU-6 as a past or current source of groundwater contamination. In addition, the vadose zone beneath OU-6 is generally greater than 100 feet. Even if COIs were present

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beneath OU-6, they would need to migrate through this vadose zone. As described in the Section 6.7.2.2, evaporation exceeds average annual precipitation, and the wetting front from even large winter precipitation events likely has limited impact in the subsurface. As discussed in the OU-4a RI (CEC, 2019), and in Section 4.7.2.3. larger precipitation events are infrequent; and, that any impact beneath OU-6 as a result of a large precipitation event would also be infrequent and discontinuous, such that the impact would likely not be discernable in groundwater.

As presented in the OU-1 FRIR, MIW is present beneath OU-6. However, the most likely source of MIW beneath OU-6 is from the HLPs that surround the OU. Groundwater data from the OU-1 FRIR show that COI concentrations are highest beneath the HLPs and decrease beneath OU-6 (CEC, 2020). This conclusion is further supported by historical operations information from the OU-8 RI which documented releases of process fluids during HLP operations (CH2M Hill, 2010).

Based on these factors, the transport pathway to groundwater beneath OU-6 is incomplete and will be so in the future. As such, the pathway will be incomplete for the purposes of performing the risk assessment and evaluating remedial alternatives. Further evaluation of MIW related to the HLPs and groundwater transport beneath ACMS (including OU-6) is included in the OU-1 FRIR (CEC, 2020).

6.7.2.4 Transport by Wind Erosion

Wind-blown dust was monitored along ACMS perimeter from January 2005 through March 2008 (BC, 2005; BC, 2009c). Results from the monitoring program indicated that no additional air quality data were needed to perform a risk assessment on the inhalation pathway. This risk assessment was performed as described in the *Baseline Human Health Risk Assessment for the Inhalation Pathway* (BC and Foxfire Scientific, 2011). The risk assessment concluded that there is no unacceptable heath risk attributable to a dust inhalation pathway. In addition, fugitive dust prevention is being addressed in areas of ACMS, including the placement of VLT cover (ARC, 2010), indicating that VLT is an adequate dust suppressant and therefore fugitive dust from the VLT in OU-6 is likely to be minimal. Because of this and because air transport from Site facilities has been addressed on a Site-wide basis, it is not evaluated further in this report.

6.8 Conceptual Site Model

Based on the information presented in Section 6.7.2, a CSM summarizing the routes of transport and physical nature of OU-6 is presented in this section. The CSM is presented schematically in Figure 6-24. This CSM does not include exposure pathways or receptors as those will be developed in the forthcoming risk assessment as described in Section 7.0. This is a CSM for the VLT in OU-6 only and does not include a discussion of VLT in other OUs.

OU-6 contains approximately 49 million cubic yards of VLT. The VLT in OU-6 has an average height exceeding 100 feet and an estimated maximum thickness of approximately 190 feet. VLT are the leached products of the vat leach copper extraction process. Because of this controlled process, the VLT is generally chemically homogenous. COIs have a consistent range of concentrations that is likely related to variations in the ore material prior to undergoing the leaching process. The vadose zone beneath the bottom of the VLT ranges from approximately 40 to 130 feet in thickness.

Transport of COIs away from OU-6 is not expected because of the thickness of the VLT, low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. As shown on Figure 6-2, the majority of the VLT is greater than 25 feet thick and given the annual climatic conditions, it is unlikely that the thinner areas of VLT (less than 25 feet thick) present a significant area where percolation to the subsurface soil could occur.

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6.9   Results Summary

Results for OU-6 are as follows:

- In 2005, 2010, and 2018, 115 samples were collected from 54 various locations, from the ground surface up to 25 feet bgs.

- Samples were submitted for laboratory analysis of metals, radionuclides, MWMP extract, and ABA/NAG, with different analytes being analyzed depending on the investigation.

- COIs were identified by evaluating the data and comparing them to BCLs. Based on the comparison, antimony, chromium, copper, magnesium, mercury, molybdenum, selenium, radium-226, and radium-228 were retained as COIs and evaluated in the RI.

- Unlike other OUs, OU-6 is composed entirely of VLT. Because of the controlled processes used to create the VLT, there is inherent chemical homogeneity in the material.

- Some spatial geochemical variability is observed laterally in OU-6, where COI concentrations are generally within one to three orders of magnitude of one another. Some variability exists as reported in the northwest corner of the OU. This area has been subject to past excavation activities, and as a result it is possible that some of the deeper sample intervals in the area could be a mixture of VLT and underlying material.

- OU-6 contains COI concentrations above their respective BCL. Of the COIs, radium-226 was most often detected above the BCL followed by copper, mercury, selenium, molybdenum, total chromium, antimony, magnesium, and radium-228.

- Two-sample hypothesis testing was performed to assess COI differences between shallow and deep sample intervals. Based on the testing, the shallow and deep intervals areas have statistically equivalent concentrations of all COIs except radium-228, suggesting that there is limited variability by depth in the upper 25 feet of the VLT.

- VLT COI concentrations in OU-6 were also compared to the VLT that had been placed as a cover in OU-4b. In general, concentrations of most COIs between the two groups are similar. When looking at the IQR and CV, some variability is present in COI concentrations. However, the majority of IQRs and CVs of the OU-6 VLT COIs are generally lower or similar to the IQRs and CVs of the OU-4b COIs. The similarity between the two groups of VLT further suggests that the variability is low in the VLT.

- Antimony, copper, magnesium, mercury, and selenium were detected in a similar percentage of samples in both MWMP samples and the total samples. The remaining COIs (chromium, molybdenum, radium-226, and radium-228) were detected less often in the MWMP samples compared to the total samples. For chromium, molybdenum, radium-226, and radium-228, the lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in OU-6 these COIs are likely to be less mobile than the other COIs. Within the context of the MWMP results, COI mobility refers to the dissolved fraction.

- Upon review of the NPR and NNP analyses, using the NNP for PAG classification yields more uncertain results, making PAG classification using NPR a more conservative approach. Similar to the VLT in OU-4b, the majority of VLT samples fell in the uncertain and non-PAG range (12% and 48%, respectively). Approximately 40% of samples were classified as PAG, however, which is a greater percentage than that seen in the VLT from OU-4b.

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- OU-6 contains approximately 49 million cubic yards of VLT. The VLT in OU-6 has an average height exceeding 100 feet and an estimated maximum thickness of approximately 190 feet. VLT are the leached products of the vat leach copper extraction process. COIs have a consistent range of concentrations and this consistency is likely related to variations in the ore material prior to undergoing the leaching process.

- Transport of COIs away from OU-6 is not expected because of the thickness of the VLT, low average annual precipitation and high evaporation reducing physical transport by runoff, and leaching of COIs into the shallow soil and groundwater beneath the areas. The majority of the VLT is greater than 25 feet thick and given the annual climatic conditions, it is unlikely that thinner areas of VLT less than 25 feet thick present a significant area where percolation to the subsurface soil could occur.

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7.0 Risk Assessment

Methods for evaluating the potential for adverse effects to human health and ecological populations will be described in the forthcoming OU-4b, OU-5, and OU-6 HHRA and SLERA work plan. The draft work plan was submitted to the NDEP for review in November 2020 and referenced the information presented in this RI Report. It provides the crosswalk between the available dataset and its use in risk assessment. The final work plan will be submitted after approval of this Final OU-4b, OU-5, and OU-6 RI Report.

The OU-4b, OU-5, and OU-6 HHRA and SLERA work plans will be developed in accordance with the relevant U.S. EPA guidance with direction from and oversight by the NDEP. The work plans and subsequent HHRA and SLERA reports will include standard risk assessment elements including: an OU-specific CSM, definition of exposure pathways, methods for selecting constituents of potential concern and of potential ecological concern, exposure and toxicity parameters for evaluation of receptor populations relevant to current and anticipated future conditions within the OUs, and methods for calculation of risk estimates and drawing risk conclusions.

Following approval of the OU-4b, OU-5, and OU-6 HHRA and SLERA work plan, draft and final HHRA and SLERA reports will be prepared and submitted to the NDEP.

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8.0   Summary and Conclusions from OU-4b, OU-5, and OU-6

Key conclusions from OU-4b, OU-5, and OU-6 are provided in this section. OU specific conclusions are also provided in Section 4.8, Section 5.8, and Section 6.9 for OU-4b, OU-5, and OU-6, respectively.

8.1   OU-4b – Sulfide Tailings

A summary of results for OU-4b are as follows:

- COIs were identified by evaluating the data against BCLs. Based on the comparison, antimony, total chromium, copper, iron, magnesium, mercury, molybdenum, selenium, uranium, radium-226, and radium-228 were retained as COIs and evaluated in this RI.

- Several mine-related material types were observed during sampling. VLT was present at the surface of all locations and overlies sulfide tailings. A subset of the samples contained a mixture of sulfide tailings and VLT. From this classification, approximately 50% of the mine-related material samples are classified as sulfide tailings, 35% as VLT, and 15% as mixed sulfide tailings/VLT.

- OU-4b soil contains COI concentrations above their respective BCLs. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, antimony, magnesium, iron, total chromium, and radium-228.

- Some spatial geochemical variability is observed laterally and vertically in OU-4b. Two-sample hypothesis testing was performed to assess COI differences between the different material types and geographic position. The variability seen in OU-4b samples appears to be controlled largely by material type, and by the tailings area (Phase 1 or Phase 2) in which the sample is located.

- Concentrations of COIs were detected in the MWMP extract with magnesium being detected most often followed by uranium, copper, selenium, molybdenum, iron, radium-226, antimony, total chromium, mercury, and radium-228. Magnesium, uranium, selenium, and copper were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples compared to the solid/total samples.

- Using the NPR, the sulfide tailings and the sulfide tailings-VLT mix had the highest number of PAG samples at 33% and 55%, respectively. Native soil samples had the highest number of non-PAG samples at 83%. The majority of VLT samples fell in the uncertain range, with smaller percentages of PAG or non-PAG samples (12% and 6%, respectively).

- In general, the sulfide tailings have a greater percentage of samples that can be classified as PAG, compared to VLT samples. Sulfide tailings samples also have higher overall values of AGP. Pyritic sulfur, potentially acid generating sulfur, water soluble sulfate, and total sulfur were generally detected more often and at overall higher concentrations in sulfide tailings samples with respect to VLT. These differences in concentrations support that the sulfide tailings have a greater percentage of samples that can be classified as PAG. Paste pH values are generally lower in VLT samples when compared to sulfide tailings; however, based on the other analysis, VLT is less likely to be acid generating when compared to the sulfide tailings.

- The CSM describes post-process solid materials from sulfide ore beneficiation that were emplaced within the Phase 1 and 2 tailings embankments described in Section 2.2.1. The majority of OU-4b is composed of sulfide tailings, along with VLT cover materials. Sulfide containing tailings were generated during the fine crushing of the sulfide ore during the beneficiation process. After the removal of the copper sulfides through a floatation process, the fine-grained (fine sand, silt, and clay sized) tailings were deposited as a slurry in designated areas within the tailings

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embankments. Following deposition, the tailings were covered with VLT to control dust. Because the sulfide tailings and VLT cover materials were generated under extensive, controlled beneficiation processes, these materials generally display a consistent composition across OU-4b. Subsequent post-emplacement construction of the process evaporation and recycling pond in the southern portion of OU-4b resulted in some spatial variability in COIs between the northern and southern areas of the OU.

- Transport of COIs away from OU-4b is not expected under current conditions because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the sulfide tailings.

- As described in the OU-1 FRIR (CEC, 2020), OU-4b was not considered a major source of COIs in groundwater. The OU-1 FRIR states that concentrations of COIs in groundwater beneath OU-4b are generally at least 10 times lower than COI concentrations in groundwater beneath OU-4a. Historically, groundwater flow from OU-4b was to the north. However, agricultural activities over the last half century have shifted groundwater flow under OU-4b to the west and southwest. As a result, OU-4b is located hydraulically upgradient or cross-gradient of OU-4a in the Shallow and Intermediate Zones, and part of the groundwater beneath OU-4b flows toward the higher COI concentrations under OU-4a (CEC, 2020).

8.2 OU-5 – Waste Rock Areas

Results for OU-5 are provided in the following sections. Results from the South WRA are presented first, followed by results for W-3 and S-23.

8.2.1 South WRA

A summary of results for the South WRA are as follows:

- COIs were identified by evaluating the data against BCLs. Based on the comparison, copper, mercury, molybdenum, selenium, uranium, radium-226, and radium-228 were retained as COIs and evaluated in the RI.

- Several of the COIs (copper, molybdenum, selenium, uranium, and radium-226) showed a bimodal distribution, suggesting that two material types may be present in the South WRA. Based on the COI distribution and historical information for the South WRA, these material types were designated alluvium and waste rock. From this classification, approximately two thirds of the mine-related material samples are classified as alluvium and one third is classified as waste rock.

- Spatial geochemical variability is observed laterally in the South WRA. COI concentrations generally do not follow consistent trends throughout the South WRA, which likely is a result of the mechanical placement of the materials during mining operations.

- The South WRA contains COI concentrations above their respective BCLs. Of the COIs, selenium was most often detected above the BCL followed by copper, molybdenum, mercury, uranium, radium-226, and radium-228.

- Two-sample hypothesis testing was performed to assess COI differences between the different depth intervals in the upper 15 feet at locations WRSB-206 though WRSB-240. Based on the testing, the four depth intervals areas have statistically equivalent concentrations of all COIs, suggesting that there is limited variability by depth in the upper 15 feet of the South WRA.

- Concentrations of COIs also were detected in the MWMP extract with uranium and molybdenum being detected most often followed by copper, selenium, radium-226, mercury, and radium-228.

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Copper, molybdenum, and uranium were detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples as compared to the total samples.

- When looking at the NPR, NNP, and NNP with NAG, all methods indicate that the majority of materials in the South WRA are non-PAG. As such, it is likely that South WRA materials will not generate acidic pH values and acidic conditions. As described in Section 5.7, the materials in the South WRA have very limited contact with significant amounts of surface runoff or groundwater, which in addition to the non-PAG material classification would preclude acid generation from the waste rock.

- The CSM for the South WRA describes alluvium and waste rock being delivered to the South WRA and placed in a series of end dumps. The mine-related materials have not been processed unlike the mine-related material in OU-4b and OU-6. Because of this mechanical deposition, lack of processing, and as presented in the analytical results, the COIs do not show consistent trends laterally or with depth. Rather, the concentrations likely represent the variation in the material (waste rock or alluvium) that was being mined and transported to the South WRA as well as the particular area of the pile that the rock was placed at a given time. During mining, waste rock not containing appreciable amounts of copper was taken to the South WRA, low-grade ore was taken to W-3 and S-23, higher grade ore was taken to the process area. Because of this segregation prior to delivery, a consistent range of COI concentrations occurs within the South WRA. COI concentrations within the South WRA are within one to two orders of magnitude of one another. Additionally, results from 2018 and 2019-2020 and the 2010 Potential Cover Materials Evaluation are generally consistent with one another, suggesting that the ranges in concentrations from the two investigations represent the overall nature of the alluvium and waste rock.

- Transport of COIs away from the South WRA is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. Additionally, the thicknesses of the South WRA, the lack of acid-generating materials, the depth to the groundwater table, and the presence of bedrock beneath the South WRA inhibit the transport of COIs to groundwater.

8.2.2   W-3 and S-23

The RI for W-3 and S-23 has been completed and is presented in the final OU-8 PA RI/FS (Wood, 2020a). Conclusions from that document are presented again here to create a comprehensive summary of all the waste rock areas in OU-5:

- Both S-23 and W-3 contain COI concentrations above their respective BCLs. Of the COIs identified in the RI, mercury was most often detected above the BCL followed by copper, selenium, molybdenum, antimony, radium-226, and uranium.

- Spatial geochemical variability is observed both laterally and with depth in W-3 and S-23. COI concentrations generally do not follow consistent trends throughout the waste rock piles, which likely is a result of the mechanical placement of the materials during mining operations.

- Two-sample hypothesis testing was performed to assess COI differences between S-23 and W-3. Based on the testing, S-23 overall contains higher concentrations of copper and selenium, and W-3 overall contains higher concentrations of radium-226. The two areas have statistically equivalent concentrations of antimony, mercury, molybdenum, and uranium.

- Concentrations of COIs also were detected in the MWMP extract with copper being detected most often followed by selenium, antimony, molybdenum, uranium, radium-226, and mercury.

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Copper was the only COI detected in a similar percentage of samples in both MWMP samples and the total samples. All other COIs were detected less often in the MWMP samples as compared to the total samples.

- Upon review of the NPR and NNP analyses, using the NNP for PAG classification yields more uncertain results, making PAG classification using NPR a more conservative approach. For W-3, 32% of the samples had an NPR greater than three and would be classified as non-PAG. There were 30% of the samples that had an NPR less than one and would be classified as PAG; the remaining 38% of the samples fell in the uncertain range. For S-23, 6% of the samples had an NPR greater than three and would be classified as non-PAG. Lastly, 94% of the samples had an NPR less than one and would be classified as PAG. No samples from S-23 had an NPR falling in the uncertain range.

- In general, S-23 has a greater number of samples that can be classified as PAG. S-23 also has higher overall values of AGP and lower values of ANP. Pyritic sulfur, sulfate sulfur, and total sulfur were also detected more often and at overall higher concentrations in S-23 as compared to W-3.

- The CSM for W-3 and S-23 describes low-grade oxide and sulfide ore being delivered to the waste rock areas and placed in a series of end dumps. Because of this mechanical deposition, and as presented in the analytical results, the COIs in each pile do not show consistent trends laterally or with depth. Rather, the concentrations likely represent the variation in the material that was being mined and transported to the waste rock area as well as the particular area of the pile that the rock was placed at a given time. During mining, low-grade ore was taken to W-3 and S-23, higher grade ore was taken to the process area, and waste rock not containing appreciable amounts of copper was taken to the South WRA. Because of this segregation prior to delivery to W-3 and S-23, a consistent range of COI concentrations occurs within each of the individual piles. Concentrations within each pile are generally within one to two orders of magnitude of one another. Additionally, results from the 2018 PAI and the 2010 Potential Cover Materials Evaluation are generally consistent with one another, suggesting that the observed variability is representative of the nature of the waste rock.

- Surface transport of COIs away from W-3 and S-23 is not expected because of low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. Additionally, the thicknesses of the waste rock piles, the depth to the groundwater table, and the presence of bedrock beneath W-3 and S-23 inhibit the transport of COIs to groundwater.

8.3   OU-6 – Oxide Tailings

A summary of results for OU-6 are as follows:

- COIs were identified by evaluating the data and comparing them to BCLs. Based on the comparison, antimony, chromium, copper, magnesium, mercury, molybdenum, selenium, radium-226, and radium-228 were retained as COIs and evaluated in the RI.

- Unlike other OUs, OU-6 is composed entirely of VLT. Because of the controlled processes used to create the VLT, there is inherent chemical homogeneity in the material.

- Some spatial geochemical variability is observed laterally in OU-6, where COI concentrations are generally within one to three orders of magnitude of one another. Some variability exists as reported in the northwest corner of the OU. This area has been subject to past excavation activities, and as a result it is possible that some of the deeper sample intervals in the area could be a mixture of VLT and underlying material.

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- OU-6 contains COI concentrations above their respective BCLs. Of the COIs, radium-226 was most often detected above the BCL followed by copper, mercury, selenium, molybdenum, total chromium, antimony, magnesium, and radium-228.

- Two-sample hypothesis testing was performed to assess COI differences between shallow and deep sample intervals. Based on the testing, the shallow and deep intervals areas have statistically equivalent concentrations of all COIs except radium-228, suggesting that there is limited variability by depth in the upper 25 feet of the VLT.

- VLT COI concentrations in OU-6 were also compared to the VLT that had been placed as a cover in OU-4b. In general, concentrations of most COIs between the two groups are similar. When looking at the IQR and CV, some variability is present in COI concentrations. However, the majority of IQRs and CVs of the OU-6 VLT COIs are generally lower or similar to the IQRs and CVs of the OU-4b COIs The similarity between the two groups of VLT further suggests that the variability is low in the VLT.

- Antimony, copper, magnesium, mercury, and selenium were detected in a similar percentage of samples in both MWMP samples and the total samples. The remaining COIs (chromium, molybdenum, radium-226, and radium-228) were detected less often in the MWMP samples compared to the total samples. For chromium, molybdenum, radium-226, and radium-228, the lower detection frequencies in the MWMP samples compared to the solid/total samples suggests that in OU-6 these COIs are likely to be less mobile than the other COIs.

- Upon review of the NPR and NNP analyses, using the NNP for PAG classification yields more uncertain results, making PAG classification using NPR a more conservative approach. Similar to the VLT in OU-4b, the majority of VLT samples fell in the uncertain and non-PAG range (12% and 48%, respectively). Approximately 40% of samples were classified as PAG, which is a greater percentage than that seen in the VLT from OU-4b.

- OU-6 contains approximately 49 million cubic yards of VLT. The VLT in OU-6 has an average height exceeding 100 feet and an estimated maximum thickness of approximately 190 feet. VLT are the leached products of the vat leach copper extraction process. COIs have a consistent range of concentrations and this consistency is likely related to variations in the ore material prior to undergoing the leaching process.

- Transport of COIs away from OU-6 is not expected because of the thickness of the VLT, low average annual precipitation and high evaporation reducing physical transport by runoff and leaching of COIs into the shallow soil and groundwater beneath the areas. The majority of the VLT is greater than 25 feet thick and given the annual climatic conditions, it is unlikely that thinner areas of VLT less than 25 feet thick present a significant area where percolation to the subsurface soil could occur.

8.4   OU-4b, 5, and 6 Transport Pathways

Based on the conclusions presented in Section 8.3, there are similarities between OU-4b, OU-5, and OU-6 in terms of the potential for transport of COIs from each OU. In general, the pathways relating to transport by water erosion/surface water runoff, leaching/percolation to subsurface soil, and transport to groundwater are incomplete for OU-4b, OU-5, and OU-6.

8.5   Future Work

The data sets and evaluation presented in this report adequately describe the nature and extent of COIs in OU-4b, OU-5, and OU-6. Sufficient data have been collected to develop an HHRA and SLERA for the OUs.

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This report, in conjunction with forthcoming HHRA and SLERA, is sufficient to provide the basis for identifying remedial action objectives and provides the information to develop the Feasibility Study.

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